Preface

The information contained in this document applies to the National Aeronautics and Space Administration (NASA) Goddard Space Flight Center (GSFC) Network Control Center (NCC), Flight Dynamics Facility (FDF), and the White Sands Complex (WSC) for the TDRS H, I, J Era. In this document, detailed definitions of the electronic high-speed message interfaces between the WSC and the NCC, and between the WSC and the FDF are covered.

The detailed definition of the communications interface between the NCC/FDF and the WSC as configured for support of Space Network (SN) operations is provided. The NCC, FDF, and the WSC are three elements of the SN that provide support to user spacecraft using the Tracking and Data Relay Satellite System (TDRSS). This document and similar documents for other elements of the SN will be used to define and control the configuration of the SN.

This document may be updated by Documentation Change Notice (DCN) or by complete revision.

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Section 1. Introduction

1.1 Purpose

The purpose of this document is to provide detailed definitions of the electronic high-speed message interfaces between the National Aeronautics and Space Administration (NASA) White Sands Complex (WSC) and the Goddard Space Flight Center (GSFC) Network Control Center (NCC), and between the WSC and the GSFC Flight Dynamics Facility (FDF), during TDRS H, I, J Era.

1.2 Scope

This Interface Control Document (ICD) defines and controls the applications functions, communications protocol, messages and block formats of the interface between the NCC/FDF and the WSC. The definition contained herein, although specified for the Second TDRSS Ground Terminal (STGT), (Danzante), apply to the STGT and the White Sands Ground Terminal Upgrade (WSGTU), (Cacique), i.e., to the WSC.

This document originated as the Appendix D, Operational Systems Interface Requirements (OSIR), to the STGT Phase II Requirements Specification. The STGT Phase II Specification was replaced by the Requirements Specification for the Danzante Ground Terminal (530-RSD-Danzante) and the Interface Control Document (ICD) between the Network Control Center (NCC)/Flight Dynamics Facility (FDF) and the White Sands Complex (WSC), 530-ICD-NCC-FDF/WSC. Both documents are traceable to the Phase II Requirements Specifications for the STGT Ground Terminal (P-01) through DCN 17. Additional modifications to the 530-ICD-NCC-FDF/WSC were (1) to replace Section 10 with reference to STDN 108, PN Codes for use with the TDRSS, (2) to incorporate TDRS H, I, J interface specifications, and (3) to incorporate as built changes to the Ground Terminal that were implemented by the WSC Maintenance and Operations (M&O) contractor after acceptance of the station (i.e. 1000 series STGT CCRs). For the TDRS H, I, J modifications to the WSC, 530-RSD-Danzante and the 530-ICD-NCC-FDF/WSC have been superseded by 405-TDRS-RP-SY-011 and 405-TDRS-RP-ICD-001 respectively. This interface control specification (405-TDRS-RP-ICD-001) was created from the 530-ICD-NCC-FDF/WSC, Revision 3 by removing approved but not yet implemented CCRs, and incorporating 530-ICD-NCC-FDF/WSC, Revision 3 approved but not yet published CCRs which have been implemented at the WSC commensurate with WSC software delivery baseline 95005.

1.3 Time Frame

This ICD shall be in effect from the date of approval by the Mission Operations and Data Systems Directorate (MO&DSD) Configuration Control Board (CCB), the Networks Division (ND) CCB, the Flight Dynamics Division and when applicable signatures are obtained.

1.4 Applicable Documents

This section lists the specifications, standards, and other documents which serve as references for supplemental descriptive information.

1.4.1 Specifications

a. Network Control Center Data System (NCCDS) Detailed Requirements, 530-DRD-NCCDS.

b. Functional Specification, 50 Mbps Statistical Multiplexer, Specification No. 841-79-05.

c. Network Control Center Data System Specification, Volumes 1 and 2, 530-SSD-NCCDS.

d. White Sands Complex (WSC) Ground Terminal Requirements for the TDRS H, I, J Era, 405-TDRS-RP-SY-011.

1.4.2 Standards

a. NASCOM Interface Standard for Digital Data Transmission (NISDDT), 542-003.

b. IRIG Standard Parallel Binary Time Code Format, X-814-77-64.

1.4.3 Other Documents

a. Digital Data Source/Destination and Format Codes Handbook for the Nascom Message Switching System, 542-002.

b. Tracking and Acquisition Handbook for the Spaceflight Tracking and Data Network, STDN No. 724.

c. Space Network Users' Guide, STDN No. 101.2

d. Support Identification Code Dictionary, 534-808.

e. PN Codes for use with the Tracking and Data Relay Satellite System (TDRSS), STDN No. 108.

Section 2. Interface Definition and Ground Rules

The messages exchanged between the STGT and the NCC/FDF are generated in the Space to Ground Link Terminal's (SGLT's) at the STGT and in the NCC/FDF at the GSFC. The interface between the SGLT's and NCC is provided by the Data Interface System (DIS) at the STGT. The messages interchanged between the SGLT's and the DIS are shown in Figure 2-1. The protocol and descriptions of the messages between the NCC/FDF and STGT are contained in this ICD.

2.1 Interfaces

The SGLT's interface with the DIS is via the DIS Secure Voice/Data Switch and the Black Data Switch. All messages described in the following sections are exchanged via these interfaces. The DIS provides the acknowledge/retransmit protocol between the SGLT and the NCC/FDF.

2.1.1 NCC to STGT Messages

NCC to STGT messages, consisting of scheduling order messages (SHO's) and operations messages (OPM's), shall be transmitted by the DIS to the SGLT's.

2.1.2 STGT to NCC/FDF Messages

STGT to NCC messages, consisting of operations messages (OPM's), TDRSS Service Level Reports (SLR's), and operations data messages (ODM's) shall be transmitted from the SGLT's to the NCC via the DIS. STGT to FDF messages consist of Tracking Data messages (TDM's) and are also transmitted from the SGLT's and relayed to the FDF via the DIS. Acknowledgment shall be requested of all OPM and SLR messages sent from STGT to the NCC, except as described below. If there is no message pending transmission to STGT, then the NCC will send a separate OPM (Acknowledgment of Message Received) to STGT. A separate OPM (Acknowledgment of Message Received) shall be used if there is no other message pending transmission to the NCC. STGT will not solicit acknowledgment of the Acknowledgment of Message Received OPM. The DIS Automatic Data Processing Equipment (ADPE) shall provide the acknowledge/retransmit protocol for the STGT.

The originator shall transmit all blocks of a message before initiating the transmission of another message except for separate acknowledgement messages which shall be transmitted, as required, at the next block transmission opportunity.

No acknowledge/retransmit of tracking data messages (TDM's) and operations data messages (ODM's) is required. Section 12 describes these tracking data, format and content. Section 9.5 describes the ODM's.

2.2 Ground Rules

Ground rules applicable to the various message types defined in Section 9 (i.e., SHO's, OPM's and ODM's) are contained in the sections following.

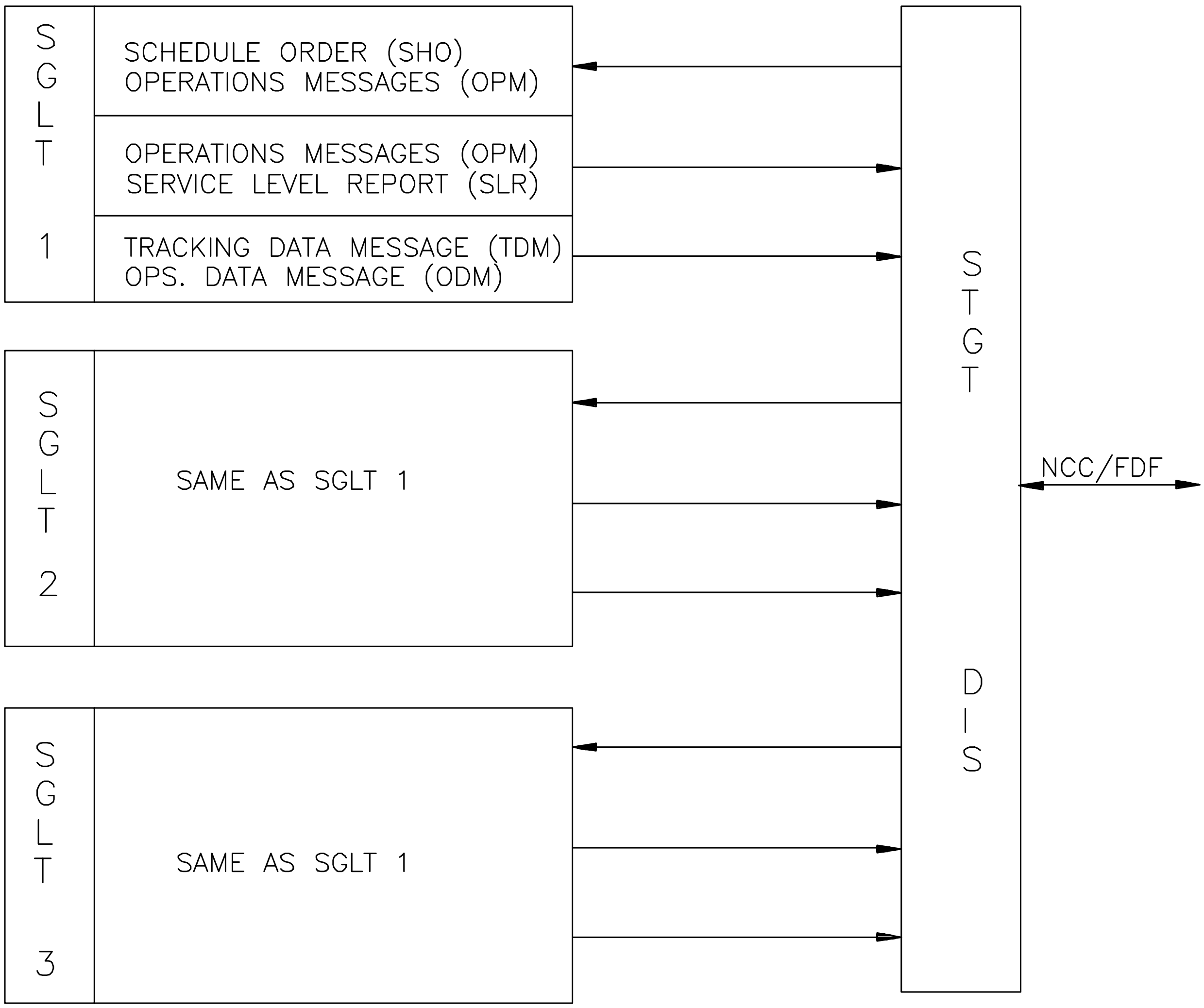


Figure 2-1. SGLT/DIS Interface

2.2.1 Vector Processing Ground Rules

<u>Section 1 - General Application</u>

This section contains the general ground rules and constraints. Before addressing the ground rules, the message class codes (MCC), state vector operations messages (OPM's), and state vector types will be discussed.

Two different message class codes (10 and 15) will be accepted for state vector OPM's (state vector messages). State vectors will be processed identically irrespective of message class code. A state vector OPM will contain one OPM header, followed by up to three sets of state vector data for a single user.

The state vector types that will be processed at STGT are as follows:

Vector Type	Application	Phase
1	Free-flight (On-Orbit)	Free-flight state vectors
2	Transition to free-flight	A type 2 vector is used only as the transition vector from maneuver sequence vectors to free-flight vectors
3		Not used
4	Ignition	First vector in maneuver sequence
5	Burnout	Last vector in maneuver sequence
6	Reentry	Landing maneuver sequence vectors
7	Launch or on-orbit	Launch or on-orbit maneuver
8	Stationary	Stationary state vectors

The following general ground rules apply:

1. Except for permanent Earth stations, user trajectory data is used according to receipt time. For each user, the most recently received vector, regardless of type, will be used from its epoch time forward. Previously received vectors with later epochs will not be used following receipt of a new vector with an equal or earlier epoch.

2. Free-flight (type 1-2) vectors will be rejected by STGT if they fail syntax, check sums, or if (1) the magnitude of the position vector is less than 6356 kilometers or (2) the epoch time of the vector is more than 12 hours earlier than the time of receipt at STGT. If a free-flight vector is rejected for any of the above reasons, a state vector reject message will be sent to the NCC.

3. Except for permanent Earth stations, no stationary state vector will be propagated more than 24 hours from its epoch time. No free-flight state vector will be propagated more than 12 hours from its epoch time.

4. A single state vector OPM may contain up to three state vectors.

5. OPM Classes 61, 64 and 65 will be sent to the NCC without TDRSS Operations and Control Center (TOCC2) operator intervention.

6. The formats for free-flight (types 1-2), maneuver sequence (types 4-7), and stationary (type 8) state vector OPM's are identical. The vector types indicate whether an OPM contains free-flight, maneuver sequence, or stationary state vectors.

7. No more than 5000 vectors received from the NCC for each user will be stored at STGT. Vectors with no future applicability will be deleted. No more than 15,000 vectors received from the NCC will be stored at STGT for all users. No more than 72 vectors for each TDRS will be stored at STGT.

The following general ground rules apply only to permanent Earth stations:

8. The NCC will provide the STGT with a list of no more than 63 permanent Earth stations. For permanent Earth stations, vector types 1 through 7 will be rejected by STGT.

9. For permanent Earth stations, the most recently received stationary vector will be used regardless of epoch. Previously received stationary vectors will not be used following receipt of a new vector.

10. There is no limit to the propagation period for permanent Earth station vectors. The permanent Earth station vectors will be retained permanently at the STGT. Permanent Earth station vectors may be updated by the NCC at any time by use of an OPM 10 or 15.

Section 2 - Maneuver Sequences

This section addresses the ground rules that are related to the use of maneuver sequences. The formats for maneuver vector sequences are shown in Table2-1.

Table 2-1. Maneuver Vector Sequence Formats

STATE VECTOR NUMBER	VECTOR TYPE	VECTOR EPOCH
1	4	t_1
2	7 (6)	t_2
.	.	.
.	.	.
.	.	.
n	7 (6)	t_n
n+1	2 (8)	t_{n+1}
n+2	7 (6)	t_{n+1}
.	.	.
.	.	.
.	.	.
n+m	7 (6)	t_{n+m-1}
n+m+1	5	t_{n+1} +6 min.

NOTES:
1. ALL MANEUVER SEQUENCES WILL HAVE THE ABOVE FORMAT.
2. THE MANEUVER SEQUENCE THAT INCLUDES THE TYPE 6 AND TYPE 8 VECTORS WILL BE USED FOR REENTRY ONLY.
3. THE VECTOR EPOCH TIME t_{n+1} IS THE END OF THE MANEUVER (TYPE 2 VECTOR) OR THE REENTRY (TYPE 8 VECTOR). THE SUBSEQUENT VECTORS IN THE MANEUVER SEQUENCE ARE SUPPLIED TO PROVIDE TIME FOR THE IMPLEMENTATION OF THE TYPE 2 AND TYPE 8 VECTORS.
4. ONLY THE 4800-BIT BLOCKS CONTAINING THE TYPE 4 VECTOR AND THE TYPE 5 VECTOR OF A MANEUVER SEQUENCE WILL HAVE THE ACKNOWLEDGEMENT BIT SET IN THE REAL-TIME MODE.

The following ground rules apply to maneuver sequences:

1. The time between epochs of successive maneuver sequence (types 4-7) state vectors can be variable, with a minimum of 0.5 second and a maximum of 6 minutes. The maximum number of vectors in a single maneuver sequence shall be 800.

2. A maneuver sequence must include at least seven state vectors. The required seven state vectors are as follows:

		1	2	3	4	5	6	7
State Vector		1	2	3	4	5	6	7
Vector Type	Launch or on-orbit maneuver sequence	4	7	7	2	7	7	5
	Landing maneuver sequence	4	6	6	8	6	6	5
Epoch		t_1	t_2	t_3	t_4	t_4	t_5	t_6

where $t_6 = t_4 + 6$ minutes

3. Between transmission of the type 4 vector of a maneuver sequence and the type 5 vector of that sequence, only those vectors in that sequence should be transmitted. For a user in the real-time mode (see Section 4), receipt of any other vector for any user Support Identification Code (SIC) will result in STGT generation of a type 2 or 8 vector (as appropriate), a type 5 vector to terminate the sequence and notification to the NCC of this action. For a user not in the real-time mode, receipt of any other vector for any user SIC will result in STGT rejection of the entire sequence.

4. A type 2, 6, or 7 vector will be rejected if it is not received as part of a maneuver sequence. For users in the real-time mode, a maneuver sequence received without a type 2 or 8 vector will be used as received and STGT will generate a type 2 or 8 vector (as appropriate). The type 2 or type 8 vector will be generated with the identical components and epoch of the last correctly received vector. For users not in the real-time mode, a maneuver sequence received without a type 2 or 8 vector will be rejected.

5. No reasonableness checks or gross validity checks are made for maneuver sequences. Syntax checks and checksum verification are performed for maneuver sequences.

Section 3 - Delta-T Applications

This section addresses the ground rules and constraints that are related to the use of Delta-T OPM's to shift the epoch times of maneuver sequences and other vectors that are in place at STGT. The epoch shifts are applied to vectors in an Earth-fixed, rotating coordinate system. The purpose of the Delta-T function is to adjust for any launch slips that occur during the launch phase of Shuttle missions.

There are several important terms associated with the use of the Delta-T OPM function that need to be defined. These are as follows:

1. The Delta-T adjustment in the Delta-T OPM is the change in the current epoch times of the vectors.

2. The original epoch of a vector in the STGT is the epoch of the vector as transmitted to STGT.

3. The current epoch of a vector in the STGT is the original epoch of the vector plus the sum of all Delta-T adjustments received at STGT.

The following ground rules apply to the use of Delta-T OPM's:

1. Application of a Delta-T OPM does not change any SHO start or stop times.

2. The Delta-T adjustment is always calculated from the current epochs of the vectors because Delta-T adjustments are cumulative.

3. A Delta-T OPM must be received at STGT at least 30 seconds prior to launch to ensure application. Delta-T OPM's arriving later will be applied as soon as possible.

4. A series of Delta-T OPM's may be sent for a given user. They will be applied successively as they arrive.

5. Delta-T adjustments may be positive (delay) or negative (advance), but the absolute value of the Delta-T adjustments must be less than 12hours.

6. The Delta-T adjustments will be applied to all vectors that are in place at the receipt time of the Delta-T OPM. It will not be applied to vectors subsequently received at STGT.

7. A Delta-T OPM must not be transmitted between transmissions of the type 4 and type 5 vectors of a maneuver sequence for the same user.

Section 4 - Real-Time Mode

This section addresses the ground rules that are related to operations in the real-time mode at STGT.

1. A user will enter the real-time mode upon receipt of any of the following messages less than 6 minutes prior to the start of service or during service:

    a. Delta-T message.

    b. Type 1 or 8 vector with an epoch prior to the end of service.

    c. Type 2, 4, 5, 6, or 7 vector as part of a maneuver sequence and with an epoch in the future and prior to the end of service. Real-time maneuver sequence support will not begin until there are at least two maneuver vectors at STGT with epochs in the future.

2. The user will remain in the real-time mode until completion of updating of the user ephemeris. This will generally be within 30 seconds of receipt of the OPM or in the case of a maneuver, 30 seconds after receipt of the last vector in the sequence. (Receipt of multiple Delta-T OPM's may delay implementation.)
3. The STGT will notify the NCC when a user enters and exits the real-time mode.
4. Acknowledgement of all blocks of a maneuver sequence shall be requested if the epoch of the Type 4 vector is more than 7 minutes later than start of transmission. If the epoch of the Type 4 is less than 7 minutes later than start of transmission, only the blocks containing the type 4 vector and the type 5 vector shall request acknowledgement.
5. There can only be one real-time user per SGLT at any given time.
6. Once maneuver sequence support in the real-time mode has begun, if current time passes the epoch of the last maneuver sequence vector at the STGT, the remainder of the sequence will be rejected and maneuver sequence support will be terminated.

2.2.2 Schedule Order (SHO) Ground Rules

The following ground rules apply to routine service scheduling:

1. In a SHO structure, the sequence of the data sets for the normal services is: Forward - Return - Tracking. Sections 9.2.3.15 and 9.2.3.17 describe how End-to-End Test data sets are incorporated into a SHO structure.
2. Periodic SHOs (type 8) shall be used to schedule user services whose start times are greater than or equal to 2 hours and less than 48 hours from receipt of the SHO at STGT.
3. Routine SHOs (type 2, Classes 1 and 3) shall be used to schedule user services whose start times are greater than or equal to five minutes and less than two hours from receipt of the SHO at STGT. These SHOs will be rejected (OPM-51, Problem Code 1) if a service start time is less than five minutes from receipt at STGT.
4. Shuttle does not use MA services, and therefore does not use cross-support. All MA service parameters and all cross-support parameters apply only to normal users.
5. Deleted.
6. The service reconfiguration period (the interval between the stop time of a SHO and the start time of the next SHO on the same Single Access (SA) antenna or using the same Multiple Access (MA) return link ID or using the same MAF link) will be at least 30 seconds. The NCC will ensure that the service reconfiguration period is adequate for slewing the SA antenna to the user position. A slew rate of approximately 0.25°/sec. is assumed. If the service reconfiguration period is less than three (3) minutes, pre-service testing is not required.
7. All SHO's have a unique SHO ID. If a SHO is to be replaced, it will be cancelled by a Cancel SHO Request, OPM-Class 12, prior to sending the replacement SHO.

8. The minimum and maximum times which may be contained within the contiguous time interval covered by a SHO are one minute (minimum time) and 24 hours (maximum time).

9. Schedule conflicts will result in the discard of the later received SHO which caused the conflict and the generation of a conflict message (OPM) which will be sent to the NCC. All previously planned and currently ongoing services will continue.

10. Two separate SHO's cannot schedule back-to-back user support periods on the same link without service interruption, i.e., service reconfiguration periods must be provided. Back-to-back (or overlapping) user support periods may be scheduled by separate SHO's on different uniquely steerable links.

11. When requested in the SHO, return link time delay data will be provided on the equipment configuration in use at the start and conclusion of service, when the equipment configuration changes and at reconfigurations during the service period. These return link time delay data will be sent after service termination.

12. All services in the SHO must cover a contiguous time period. During the time interval from the earliest service start time to the latest service stop time in the SHO, there must not be any period for which no service is being provided to the user. Within a SHO, the minimum time between the stop time of a service and the start time of the same service shall be 15 seconds. MA Return (MAR) Channel availability is based on the assumption that a MAR Channel is allocated to a SHO from the earliest MAR service start time to the latest MAR service stop time in the SHO. Overlapping of MAR services in a SHO shall be rejected by the STGT. This ground rule applies to SMAR also.

13. All services in the SHO must be for the same TDRS. With the exception of S-band Single Access (SSA) combining, all services in the SHO shall be for the same TDRS SA antenna.

14. For tracking services, the related forward and/or return services must be scheduled for the entire duration of the tracking service and must be described in the same SHO. Simultaneous SSA and Ku-band Single Access (KSA) services from the same SA antenna must be described in the same SHO.

15. For optimal performance, all coherent services (i.e., Data Group 1 (DG-1) Modes 1 and 3 and all coherent carrier services) should have the forward and return services starting at the same time. If operational considerations require starting the forward service before the return service, no reconfigurations of the forward service (i.e., OPMs 02, 03, and 11) shall be sent within 30 seconds of the start of return service. OPM 04 shall not be sent within 150 seconds of the start of the return service. These messages will not be rejected, but could cause inaccuracies in subsequently scheduled tracking data.

16. For a User Reconfiguration Request OPM, the reconfigurable parameters shall be contained in the Reconfiguration OPM. The SHO contains the initial configuration (the fixed parameters plus the initial group of reconfigurable parameters for that service).

17. Deleted.

18. Deleted.

19. All SHO's (periodic and routine) shall have the same format.

20. The SHO ID is unique for each new schedule. A SHO retains the same ID for each subsequent schedule change or deletion for reference purposes.

21. The first data block containing scheduling data must be flagged for message acknowledgment in the TDRSS header, i.e., SHOs require acknowledgment of successful receipt by STGT. The message acknowledgment will occur after the successful receipt of all blocks comprised in the message.

22. Each scheduling data message (single block or multiblock) can contain only one SHO. This constraint makes a SHO and a scheduling data message synonymous.

23. Scheduling order data and operations messages cannot occupy the same 4800-bit block.

24. A scheduling order data message is limited to a maximum group of 15 blocks.

25. The maximum number of services in a SHO is 16. An SSA combining service counts as two, i.e., there will only be one set of SSA Return (SSAR) parameters in the SHO with the SSA combining byte set to 1 = yes, however, this counts as two services. The SSA combining parameters shall be specified as SSA1 parameters.

26. At any point in time, the number of SHOs awaiting execution shall not exceed 600.

27. Deleted.

28. The Support Identifier Code (SUPIDEN) is a spacecraft-unique coded number assigned by NASA. For the TDRS series, the SUPIDENs have been assigned as follows:

    TDRS Serial #1 (F-1) = TDRS A = SUPIDEN 1300
    TDRS Serial #2 (F-2) = TDRS B = SUPIDEN 1301
    . .
    . .
    . .
    TDRS Serial #10 (F-10) = TDRS J = SUPIDEN 1309

    Although the TDRS may not be launched in this ordered sequence, these designations are fixed and shall not change.

29. For KSA/KaSA and SSA DG2, Staggered Quadrature Phase Shift Keying (SQPSK), Single User coded data service (where concurrent encoder symbols are placed on the I and Q phase of the SQPSK carrier), it is necessary that the user's I and Q phase relationship be known in order to properly decode the user data. The definition of the I Channel G2 Inversion parameters, in this case is as follows:

    G2 Inversion - I Channel

    0 = G2 polynomial normal - I leads Q, or
    G2 polynomial inverted and I lags Q

    1 = G2 polynomial inverted - I leads Q, or
    G2 polynomial normal and I lags Q

30. The four character SIC for a user spacecraft is the same as the four numeric characters of the user SUPIDEN. The second through the fifth characters of the SUPIDEN, along with the Vehicle Identification Code (VIC) are used to identify the User and, in turn, to correlate SHO's with the User spacecraft state vector.

31. Definition of Effective Isotropic Radiated Power (EIRP) - The user spacecraft minimum and maximum EIRP (paragraphs 9.2.3.8, 9.2.3.10, 9.2.3.12) over the scheduled service period are defined as follows:

$$EIRP(t) = EIRP_u(t) - 20 \log \frac{R_u(t)}{R_{spec}} + n \text{ dBW}$$

where:

EIRP(t)	is the User's apparent EIRP, assuming the User spacecraft is located at a range R_{spec} from TDRS.
$EIRP_u(t)$	is the time User's actual EIRP based on the User's transmitter power, antenna gain, efficiency, and pointing losses.
$R_u(t)$	is the time varying range of the user spacecraft from TDRS.
R_{spec}	is the range of the user spacecraft from TDRS corresponding to a propagation space path loss of -192.2 dB for S-band and -209.2 dB for K-band.
n	is a factor which accounts for antenna polarization loss due to imperfect circular polarization of the User spacecraft transmit antenna.

Hence, $EIRP_{max}$ is the maximum value of EIRP(t) and $EIRP_{min}$ is the minimum value of EIRP(t) over the scheduled service period. STGT shall use the minimum EIRP value, in conjunction with TDRS performance parameters, to compute a C/N_o for configuring the IR. Maximum Data Rate values shall be provided in the SHO.

For User End-to-End Test Services, the "EIRP of Simulated User" (paragraph 9.2.3.15) is EIRP(t) at the return End-to-End Test service start time.

32. For a User transmitting DG1 data from a single source by Quadrature Phase Shift Keying (QPSK) modulation, the SHO data rate for the I and Q channels should be set to the same value - that which is the data rate of the user single source. However, if either I or Q modulator of the user is inoperative, then that corresponding I or Q channel data rate should be set to a value of zero in the SHO. For DG2, the I and Q Channel data rates shall be one-half the single source data rate.

33. For a user transmitting data by Binary Phase Shift Keying (BPSK) modulation, the SHO data should be as follows:

DG1 -	I Channel only:	Specify I channel data rate only;set Q Channel data rate to American Standard Code for Information Interchange (ASCII) space.
DG1 -	Q Channel only:	Specify Q channel data rate only; set I channel data rate to ASCII space.

DG2: data rate	Specify I channel data rate; set Q channel to ASCII space.

34. For a User transmitting either QPSK or BPSK from a single data source, the constraints of 32 and 33 above, which specify I and Q values for the SHO data rate parameters, also apply to these other SHO parameters:

    Data Format
    Data Bit Jitter
    Data Coding
    Symbol Format Conversion
    G2 Inversion

35. On a TDRS, there is a single polarizer for S-band and another single polarizer for K-band. Therefore, for SHO's and user reconfiguration OPM's, the antenna polarization parameter code (0 = Left-hand Circular Polarization (LCP), 1 = Right-hand Circular Polarization (RCP)) for simultaneous forward and return services, (either SSA or KSA) which use a single SA antenna, must be the same.

36. Simultaneous MA Forward (MAF) or SMAF, SSA Forward (SSAF), and KSA Forward (KSAF/KaSAF) services to a single user shall be provided. These services will be requested in a single SHO. The maximum number of simultaneous forward services for a single user in one SHO is three; one MAF or SMAF, one SSAF, and one KSAF/KaSAF.

37. For users sending "idle pattern" (no useful data), the SHO shall contain the baud rate in the reconfigurable parameters but zero in the data rate in SHO Subheader 6. If reconfiguration of the channel is not required, the SHO Subheader shall contain an "N".

38. EET Services, SSA Combining and Cross Support Services shall be required. Any two of these three capabilities shall be supported simultaneously. Simultaneous support of all three is not required.

39. The Data Quality Monitor (DQM) Sync Strategy Parameters are defined as follows:

    a. N1, Number from 0 to 5 bit errors allowed for acceptable sync word detection in the search, check,lock, and flywheel modes.

    b. N2, Number from 1 to 5 of consecutive, detected sync words in the check mode.

    c. N3, Number always equal to 1, undetected sync words in the lock mode.

    d. N4, Number from 0 to 5 of consecutive, undetected sync words in the flywheel mode.

    e. N5, Enable/Disable of best match strategy in the search mode (1 = enable, 0 = disable).

40. DIS Pre Service Test (PST) shall not be performed when any DIS Shuttle chain is already assigned. A DIS Shuttle chain is assigned from the earliest SHO service start time minus PST period to last service stop time.

41. The minimum value of theMax Data Rate parameter in a SHO shall be 1000 bps.

42. For users transmitting from a single source by QPSK modulation, only the I Channel data of Subheader 6 is applicable. For users transmitting BPSK, the applicable channel of Subheader 6 is as specified in Ground Rule 33.

43. MA services are applicable for TDRS A-G only. SSA and KSA services are applicable for TDRS A-J. SMA and KaSA services are applicable for TDRS H-J only. Incorrectly scheduled services for a TDRS shall be rejected.

44. Simultaneous scheduling of Ku and Ka Band services on the same SA antenna is not permitted.

45. Ka-Band services are DG-2, noncoherent only. There are no tracking services at Ka-Band.

2.2.3 End-To-End Test (EET) Data Ground Rules

The following ground rules apply to End-to-End Test SHO's:

1. Deleted.

2. End-to-End Test services cannot be scheduled alone, i.e., the related traffic services must be included in the SHO.

3. In an End-to-End Test SHO, the start time specified in an End-to-End Test data set must be the same as that of the related traffic service and the stop time in the End-to-End Test data set must be the same as that of the related traffic service.

4. End-to-End Test services cannot be included in a normal SHO. An End-to-End Test SHO must be used for End-to-End Test services.

5. All End-to-End Test SHO reject messages shall be sent to the NCC without operator intervention.

6. Shuttle End-to-End Test and pre-service test shall not overlap on the same SA antenna on any TDRS, e.g., if Shuttle End-to-End Test services are on-going on SGLT1 SA-1, then in order to avoid conflict, schedule overlapping Shuttle pre-service tests on SA-2 of SGLT1, 2 or 3, i.e., not on SA-1 of SGLT2 or 3. Shuttle SHO's shall not be rejected if End-to-End Tests and pre-service tests overlap, i.e., the Shuttle SHO shall be serviced without pre-service test.

7. End-to-End Test services which use forward and return data from NASA shall be reconfigurable by OPM classes 02 (return only), 03, and 11. Local mode End-to-End Tests shall not be reconfigurable.

8. Shuttle End-to-End Tests shall be supported only in the local mode.

9. EET EIRP calibration shall be performed during preservice testing.

10. There will only be one S-band (forward and return) and one K-band (forward and return) service per EET SHO. The EIRP of the return EET service shall not be reconfigured.

11. An End-to-End Test SHO which does not have a three minute Preservice Test period shall be rejected with a Problem Code 6 in OPM 51.

12. End-to-End Test for Ka services is not applicable. End-to-End Test SHO’s for Ka services shall be rejected with an OPM 51 Problem Code of 18 (End-to-End Test SHO format error).

13. Shuttle End-to-End Test (EET) services (S-Forward, S-Return, K-Forward, K-Return) shall not be required simultaneously. These EET services shall be scheduled with separate EET SHO’s.

14. In order to prevent RF interference with S-band Command and Telemetry, the following S-band EET frequency ranges are excluded:

EET Forward	2031 to 2041 Mhz
EET Return	2206 to 2216 Mhz

15. EET Forward and Return frequencies for non-coherent carrier services are constrained as follows:

    [Return Frequency - (240/221) Forward Frequency] $\leq$ 1 Mhz (S-Band)

    [Return Frequency - $\left(\frac{1600}{1469}\right)$ Forward Frequency] $\leq$ 1 Mhz (K-Band)

    Non-coherent Forward and Return carrier frequencies cannot be reconfigured by more than 1 MHz.

16. Forward EET services shall always be scheduled with Doppler compensation enabled. For Shuttle SSAF EET services, Doppler compensation of both carrier and PN rate shall be scheduled.

2.2.4 Operations Message (OPM) Ground Rules

The following ground rules apply to operation messages:

1. A message (single or multiblock) shall not contain more than one OPM.

2. OPM's sent by the NCC to STGT which require processing shall be contained in one 4800-bit block message. OPM's which do not require processing (text messages) may contain 1 to 15 4800-bit blocks.

3. The reference to a SHO from a service-related OPM is by SHO ID, TDRS ID, and link ID (service support type and subtype).

4. An OPM received at the STGT which references a specific service is valid only for an ongoing service. An OPM which applies to all services in the referenced SHO (i.e., cancel SHO OPM) is valid at any time prior to the termination of the last service in the referenced SHO.

5. NASA has assigned the following numbers:

	SIC	VIC
STGT	1540	01
WSGTU	1373	01

6. A reacquisition OPM will be rejected if there is an inoperative status indication for any equipment in the string being used for that service and an OPM reject message will be sent to the NCC.

7. All outbound OPM’s will be sent to the NCC without TOCC2 intervention.
8. MA OPMs apply to TDRS A-G only. KaSA and SMA OPMs apply to TDRS H-J only. Incorrectly received OPMs for TDRS capabilities shall be rejected.

2.2.5 Operations Data Messages (ODM’s) Ground Rules

The following ground rules apply to ODM’s:

1. An ODM may consist of 1 to 15 4800-bit data blocks.
2. ODM’s are sent to the NCC once every five seconds for ongoing (including End-to-End Test) services only.
3. The first ODM to report on a specific service will be sent within five seconds of the service support start time and the last message to report that service will be sent within five seconds of the service stop time.
4. Separate SA/SMAR, MA/SMAF and End-to-End Test ODMs will be used to report the active services for each TDRS. These ODMs shall not be combined within a single message.
5. An ODM does not require an acknowledgment of message received.
6. An End-to-End Test ODM can report data for up to 4 (two forward, and two return) End-to-End Test services.
7. When an End-to-End Test service is active, an End-to-End Test ODM shall be sent to the NCC in addition to any other SA or MA ODMs.
8. In ODM’s, Radio Frequency (RF) beam-pointing data associated with a user are not reported when a End-to-End Test service (for the User) is ongoing. Instead, the RF beam-pointing data reported shall be derived from the simulated user being located at STGT.
9. In an ODM if a parameter is not applicable, then the value for the parameter will be set to ASCII space.
10. For SQPSK services in which alternate bits/symbols of the I and Q Channels are interleaved to form a single data channel, the Bit Error Rate (BER) status in the ODM’s shall be reported under the I Channel.

Section 3. Interface Requirements

The messages exchanged on the STGT-NCC/FDF interfaces are constructed as 4800-bit data blocks (600 8-bit bytes). The 600 bytes which make up the 4800-bit data blocks are individually numbered in Figure 4-1.

Except as otherwise noted in detail diagrams or text, all characters or digits are ASCII. All numbers are expressed in decimal except as otherwise noted. Also, unless otherwise noted, in a horizontal format presentation, the most significant bit, byte or digit is leftmost and the least significant bit, byte or digit is rightmost in the diagrams. In a tabular format presentation, the most significant bit, byte or digit is at the top and the least significant bit, byte or digit is at the bottom. The message formats contained herein are presented relative to the manner that these data are contained in registers or computer memory sequential byte addresses. In sending messages from the STGT to the NCC/FDF or from the NCC/FDF to the STGT, order of transmitting a string of bytes (which make up the message) shall proceed from the most significant byte to the least significant byte, and the order of transmitting the bits of each byte (except TDMs for Johnson Space Center (JSC)) shall proceed from the most significant bit to the least significant bit.

Where messages contain date and/or time, the date is a decimal number, where January 1st = 001 and December 31 = 365 (or 366, during a leap year) and time is Greenwich Mean Time (GMT). In message structures, the codes which are not shown are illegal and shall not be used. Where a code is shown as "not applicable" for a particular message, the characters will be set to an ASCII space (blank) or any other legal value. For example, the parameter for Command Channel Pseudonoise (PN) modulation is not applicable for forward data rates above 300 Kbps and that character must be set to an ASCII space or any other legal value. Also in cases where a parameter will not be used it must be set to ASCII space or any other legal value. For example, in a coherent return service the forward service frequency establishes the receive frequency and this parameter may be set to ASCII space (except for Shuttle).

In any case where a field is defined to have more characters than are being used, data is to be right-justified (unless otherwise specified). Whenever such a field is defined to contain numeric data, the unused characters at the left of the field are to be filled with ASCII zeroes (unless otherwise specified). Whenever such a field is defined to contain anything other than all numeric data, the unused characters at the left of the field are to be filled with ASCII blanks (unless otherwise specified).

3.1 Message Protocol

A message may consist of from 1 to 15 4800-bit blocks. Upon satisfactory receipt of a complete message requiring an acknowledgment, the Receiver will insert an acknowledgment of message received in a block pending transmission or a separate acknowledgment message will be sent at the next block transmission opportunity. Processing of a message shall not proceed until all blocks in a message are received successfully.

3.2 Data Block Integrity

For 4800-bit blocks transmitted from NASA to the STGT, the 22-bit remainder (for a 22-bit polynomial code), as described in Section 10, shall be used to detect transmission errors within a data block. The TDRSS header identifies the number and sequence of blocks within a multiblock message. The synchronization pattern of the network control header identifies the start of a 4800-bit block. Any block which fails the polynomial check shall not be used for computational purposes.

3.3 Transmission Control

The flag field in the TDRSS header of each 4800-bit block, as defined in Section 4, contains the transmission control bits. The "acknowledgment of message received" bit may be set in any block. The "last block" bit must be set in the last block of any multiblock message and in a single block message. The retransmission bit must be set in any and all blocks that are retransmitted. Transmission and reception of blocks within a multiblock message must occur in block number sequence. The flag bit to request acknowledgment of receipt of the message is set in the first block of a message. For messages that are retransmitted, the retransmission bit will be set and the receiver will verify that it has successfully received an earlier transmission of the message before dropping the retransmitted message. If the message has not been previously received, then the retransmitted message will be accepted. Messages transmitted without the retransmission bit set shall always be processed as though they were original message transmissions.

3.4 Error Handling

For each message sent, the Sender must indicate whether or not the Receiver is to acknowledge satisfactory receipt of the message. This is done by setting the proper bit in the protocol control flags. (See Section 6.5.)

If the Sender requests a message acknowledgment and does not receive the responding acknowledgment (contained in the acknowledgment subfield of a subsequent in-bound message) within five seconds of the completed message transmission, then the Sender shall set the retransmit flag in each block of the message and resend the entire message. Retransmitted messages shall be sent with at least equal transmission priority as original messages. The retransmitted message blocks shall have the original message ID, message type, block sequence numbers and block count. If the Sender fails to obtain a message acknowledgment for the retransmitted message within five seconds, the Sender shall send the message again. (This would be the third time that the message was sent.)

If at this point the Sender does not obtain a message acknowledgment within five seconds after resending the message, the Operator (TOCC2 or NCC) shall be notified.

Valid blocks received are retained at least 15 seconds from the time of receipt of the first block of a message. At the end of this time period, the message shall be discarded if all blocks have not been received.

There shall be no acknowledgment for any erroneous message received. Blocks shall be considered in error if they fail the 22-bit remainder check; or, for a multiblock message, if any block number within a message is received out of sequence. A message shall be considered in error if the TDRSS Header is invalid or if any block in a multiblock message is in error.

Messages in error shall not be processed.

Section 4. TDRSS/NASA 4800-Bit Block Structure

The structure of a 4800-bit data block is illustrated in Figure 4-1 in sequentially numbered 8-bit bytes. The byte numbers indicate the sending order of transmission. The byte numbers are also used to indicate the position and size of the primary and subordinate fields into which the 4800-bit data block is segmented.

The message field contains an acknowledgment subfield (except for Tracking Data Service messages; see Section 12) and a data subfield. The message field is variable length; it is made up from a selection of data items according to each message type and its required data content.

The organization of the 4800-bit block is shown in Table 4-1; the formats, coding, and orientation for the contents of the fixed fields (and subfields) are described, follow by the details for the structures and data items used in the variable subfields.

Figure 4-1. Structure of a 4800-Bit Data Block

Table 4-1. Organization of 4800-Bit Data Block

REFERENCE PARAGRAPH	BYTE #s	# OF BYTES	ITEM
5.0	1-----6	6	NETWORK CONTROL HEADER
5.1			SYNCHRONIZATION
5.2			INTERFACE TYPE
6.0	7----12	6	TDRSS HEADER
6.1			BLOCK SEQUENCE NUMBER
6.2			MESSAGE IDENTITY (ID)
6.3			FIXED PATTERN
6.4			MESSAGE TYPE
6.5			PROTOCOL CONTROL FLAGS
6.6			SPARE
6.7			NUMBER OF BLOCKS IN THIS MESSAGE
6.8			MESSAGE FIELD SIZE
7.0	13----18	6	TIME FIELD
9.0	19---596	VARIABLE	MESSAGE FIELD
9.1			"ACKNOWLEDGEMENT" SUBFIELD
9.2			DATA SUBFIELD
8.0	597---600	4	ERROR CONTROL FIELD
			SPARE
			CONTROL FLAGS
			POLYNOMIAL REMAINDER

5. Network Control Header

5.1 Synchronization Field

Byte #	1	2	3	Fixed-Sync Pattern
	01100010	01110110	00100111	

First bit sent.

5.2 Interface Type Field

This field is used to distinguish tracking data from other messages (byte 5) and to provide a unique source/destination code (byte 4) for the STGT/WSGTU. These fields are not used by the STGT/WSGTU on incoming messages.

STGT

Byte #	4	5	6	Fixed code for:
Bits	10110110	01001111	00001011	Tracking Data
Bits	10110110	10001111	00001011	SHO, OPM, SLR, and ODM

WSGTU

Byte #	4	5	6	Fixed code for:
Bits	11111001	01001111	00001011	Tracking Data
Bits	11111001	10001111	00001011	SHO, OPM, SLR, and ODM

Section 6. TDRSS Header

Byte #	7	8	9	10	11	12		
# of Bits	4	12	7	4	5	2	4	10

Message Field Size

Number of 4800-Bit Blocks in message

Spare - set to zeros

Protocol control flags

Message Type

Fixed pattern - set to 1111000

Message Identity (ID)

Block sequence number (within a message)

Note: Bytes 7 through 12 have a unique format for TDMs to be transmitted to JSC. Refer to Section 12.1.1.

6.1 Block Sequence Number

4 bits

This subfield is a binary count which indicates the sequence of each block within a message. The count starts at one and increments by one for each subsequent 4800-bit data block in a multiblock message. The range of the count is one to $15_{(10)}$.

6.2 Message Identity ID

12 bits

This subfield contains a binary number from a modulo - 2^{12} binary counter. It is used by the Sender to uniquely identify each message sent on a line.

Although multiple tracking data sets may be contained in a single 4800-bit data block the number of this subfield will be incremented by one from the preceding 4800-bit data block for tracking messages. For all other types of messages (SHO, OPM, and SLR) which use one or more 4800-bit data blocks per message, the number in this subfield will be incremented by one from the number of the preceding message for each message sent. In case of multiblock messages, all the 4800-bit data blocks of the message will contain the same value in this subfield. The range of this subfield will cycle: 0 to 4095 to $0_{(10)}$.

6.3 Fixed Pattern

7 bits - Set to 1111000

6.4 Message Type

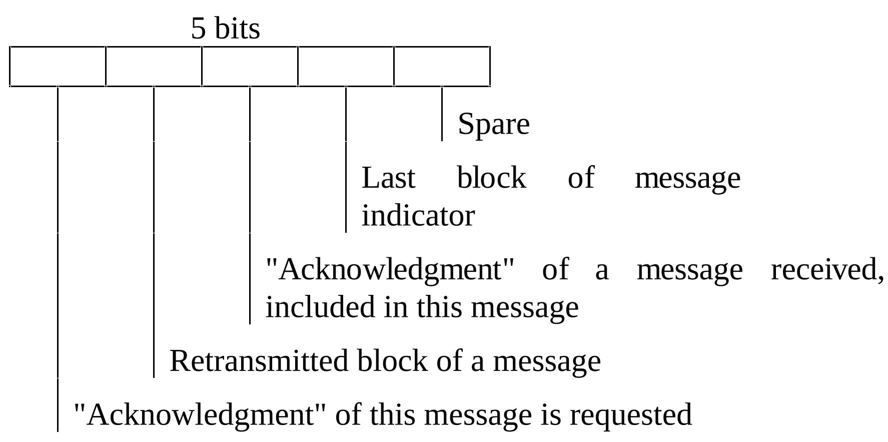
4 bits

This 4-bit binary subfield is used to identify types of messages as follows:

Decimal*	Binary	Message Type
1	0001	Tracking Data
2	0010	Scheduling (SHO) - Routine
3	0011	Operations (OPM)
4	0100	TDRSS Service Level Status (SLR)
5	0101	SA/SMAR Operations Data
6	0110	MA/SMAF Operations Data
7	0111	End-to-End Test Operations Data
8	1000	Scheduling (SHO) - Periodic Schedules

*These data are binary. The decimal values are shown only for reader convenience.

6.5 Protocol Control Flags



6.6 Spare

2 bits - Set to zeros

6.7 Number Of 4800-Bit Data Blocks

4 bits

This subfield contains a binary count of the number of 4800-bit data blocks in the message, up to a maximum of 15.

6.8 Message Field Size

10 bits

This subfield contains a binary count of the number of bytes in the message field of the 4800-bit data block. Except for Tracking Data Service messages, the message field contains an acknowledgment subfield of four bytes and a data subfield of up to 574 bytes. In all messages except tracking data messages, the acknowledgment of message received subfield is to be reserved to enable a response to a "request for acknowledgment" for messages satisfactorily received. Tracking data messages do not contain a message acknowledgment subfield. Therefore, the data subfield may contain up to 578 bytes.

Section 7. Time Field

Byte #						
	13	14	15	16	17	18

This field is required by NASA for optional insertion of a time tag; it is not required or used by STGT. For data blocks generated by the STGT, the entire time field shall be set to a logical one state.

Section 8. Error Control Field

Byte #	597	598	599	600
# of Bits	8	1	1	22

Polynomial remainder (Section 10)

Bit 4778 (NASA-Block Error Detector (BED))
- 0 = Remainder checks OK.
- 1 = Remainder does not check OK.

Bit 4777 (STGT)
- 0 = Remainder checks OK.
- 1 = Remainder does not check OK.

Spare - shall contain logical 1s.

Section 9. Message Field

The message field contains two subfields:

1. A fixed length "acknowledgment of message received" subfield in bytes 19 through 22; and
2. A variable length data subfield starting with byte 23, the message type. The remainder of variable-length message is constructed from a selection of coded data items to specify services, start/stop times, parameter setting/adjustments, reference SHOs, etc.

9.1 Acknowledgment of Message Received Subfield

When an "acknowledgment of this message" flag bit is set to a one in the TDRSS header of a message satisfactorily received, the first 32 bits of the TDRSS header from the last 4800-bit data block of that received message shall be loaded into this subfield (bytes 19 through 22) in the next available 4800-bit data block of an outbound message; otherwise, this subfield shall contain all ones. The content of the first 32 bits of the TDRSS header is described in the preceding Section 6.

If there is no such active or pending outbound message, an Acknowledgment of message received OPM message shall be initiated for this purpose. When this condition is encountered by the NCC a pseudo-supiden of "Z9999ZZ" shall be inserted in bytes 35 through 41 of OPM 03 Class 14.

9.2 Message Subfield for SHOs

Within a 4800-bit data block, bytes 23 through 596 are the message subfield. Scheduling order data (SHO) contained in this subfield, in one or more 4800-bit data blocks (up to a maximum of 15), are used to specify all the support services requested for single or dual user support for a given support period. A SHO is made up of a header, followed by a data set consisting of selected subheaders and other fixed and reconfigurable parameters for each service (Forward, Return, Tracking and End-to-End Test) to completely specify the service type, subtype, the TDRS to be used, start/stop times, and the parametric values to be employed by the TDRSS in establishing the support services. After the SHO header a data set is constructed for each service. These data sets (consisting of one or more subheaders and other parameter data) follow one another contiguously within the data subfield. If End-to-End Test services are included in the SHO, data for the End-to-End Test shall follow immediately after those data which define the related traffic services (Forward, Return, Tracking).

Processing of these successive sets of data, which define the total combination of SHO services, is controlled by the number of services requested (bytes 58-59).

Table 9-1 indicates this structure and data items for SHO's, and refers to the sections in this ICD that provide the details for data content and formats.

Table 9-1. Schedule Order (SHO) Data Message

REFERENCE PARAGRAPH	BYTE	# OF BYTES	DATA ITEM
9.2.1			SHO HEADER:*
	23-24	2	MESSAGE TYPE
	25-31	7	SHO ID
	32-33	2	SHO CLASS
	34-40	7	SUPIDEN - NORMAL USER
	41-42	2	VIC - NORMAL USER
	43-49	7	SUPIDEN - SHUTTLE
	50-51	2	VIC - SHUTTLE
	52-53	2	USER CODE ASSIGNMENT - NORMAL USER
	54-55	2	USER CODE ASSIGNMENT - SHUTTLE, K-BAND
	56	1	USER CODE ASSIGNMENT - SHUTTLE, S-BAND
	57	1	SHO SOURCE
	58-59	2	NUMBER OF SERVICES REQUESTED IN THIS SHO
	60-62	3	NASCOM/USER CHANNEL ID
9.2.2	THE LOCATION OF THESE ITEMS WITHIN A 4800-BIT DATA BLOCK DEPEND UPON THE COMBINATION OF SERVICES REQUESTED IN THE SHO		SHO SUBHEADERS:
9.2.2.1		3	SHO SUBHEADER #1
9.2.2.2		22	SHO SUBHEADER #2
9.2.2.3		1	SHO SUBHEADER #3
9.2.2.4		6	SHO SUBHEADER #4
9.2.2.5		73	SHO SUBHEADER #5
9.2.2.6		70(n)	SHO SUBHEADER #6
9.2.3			SHO SERVICES
9.2.3.1		28	MA/SMA FORWARD - FIXED PARAMETERS
9.2.3.2		94	MA/SMA FORWARD - RECONFIGURABLE PARAMETERS

Table 9-1. Schedule Order (SHO) Data Message (Cont'd)

REFERENCE PARAGRAPH	BYTE	# OF BYTES	DATA ITEM
9.2.3.3		43	SSA FORWARD - FIXED PARAMETERS
9.2.3.4		111	SSA FORWARD - RECONFIGURABLE PARAMETERS
9.2.3.5		29	KSA/KaSA FORWARD - FIXED PARAMETERS
9.2.3.6		122	KSA/KaSA FORWARD - RECONFIGURABLE PARAMETERS
9.2.3.7		58	MA RETURN - FIXED PARAMETERS
9.2.3.8		221	MA RETURN - RECONFIGURABLE PARAMETERS
9.2.3.9		67	SSA/SMA RETURN - FIXED PARAMETERS
9.2.3.10		245	SSA/SMA RETURN - RECONFIGURABLE PARAMETERS
9.2.3.11		63	KSA/KaSA RETURN - FIXED PARAMETERS
9.2.3.12		376	KSA/KaSA RETURN - RECONFIGURABLE PARAMETERS
9.2.3.13		45	TRACKING, NORMAL AND TIME TRANSFER
9.2.3.14		35	TRACKING, CROSS-SUPPORT AND TIME TRANSFER
9.2.3.15.1		114	END-TO-END TEST DATA SET FORWARD DATA
9.2.3.15.2		190	END-TO-END TEST DATA SET RETURN DATA
9.2.3.16		--	EXAMPLE OF A SHO STRUCTURE
9.2.3.17		--	EXAMPLE OF AN END-TO-END TEST SHO STRUCTURE

*These specific byte numbers apply to the first 4800-bit data block of a SHO message. The SHO header is not repeated in subsequent 4800-bit data blocks in the case where a SHO requires more than one 4800-bit data block.

9.2.1 SHO Header

The structure of the SHO header is:

Byte #	# of Bytes	Data Item
23-24	2	Message Type 1 = Tracking Data => 2 = SHO - Routine 3 = OPM (Operations) 4 = SLR (TDRSS Service Level Status) 5 = ODM (SA/SMAR Operations Data) 6 = ODM (MA/SMAF Operations Data) 7 = ODM (End-to-End Test Data) => 8 = SHO - Periodic
25-31	7	SHO ID SHO’s shall be sequentially numbered: 1 to 9,999,999 to 1
32-33	2	SHO Class 1 = Normal 2 = Spare 3 = End-to-End Test 4 = Spare 5 = Spare 6 = High Data Rate Multiplexer (HDRM) from IFL (see subheader No. 6)
34-40	7	SUPIDEN - Code assigned by NASA - normal user
41-42	2	Vehicle Identification Code (VIC) - Code assigned by NASA - normal user
43-49	7	SUPIDEN - Code assigned by NASA - Shuttle
50-51	2	Vehicle Identification Code (VIC) - Code assigned by NASA - Shuttle
52-53	2	User Code Assignment - normal user This subfield contains the code assigned for a normal (non-Shuttle) user (STDN 108)
54-55	2	User Code Assignment - Shuttle - K-Band This subfield contains the code assigned for Shuttle (STDN 108)
56	1	User Code Assignment - Shuttle, S-Band Forward This subfield contains the code assigned for a Shuttle, S-Band (STDN 108)

Byte #	# of Bytes	Data Item
57	1	SHO Source 0 = NASA - NCC 1 = TDRSS - TOCC2
58-59	2	Number of Services Requested in this SHO This subfield indicates the number of services requested in this SHO. (1-16)
60-62	3	NASCOM/User Channel ID This subfield is for NASA use to identify a channel assignment at the NCC end of the NASA Communications Network (NASCOM) link. STGT does not use these data.
	40	

9.2.2 SHO Subheaders

9.2.2.1 SHO Subheader No. 1: Service Type, Subtype, and TDRS ID

# of Bytes	Data Item
1	Service Support Type 0 = Forward 1 = Return 2 = Tracking 3 = Forward End-to-End Test 4 = Return End-to-End Test

# of Bytes	Data Item
1	Service Support Subtype
	0 = MA
	1 = SSA1 (Antenna 1)
	2 = SSA2 (Antenna 2)
	3 = KSA1 (Antenna 1)
	4 = KSA2 (Antenna 2)
	5 = SMA
	6 = KaSA1 (Antenna 1)
	7 = KaSA2 (Antenna 2)
1	TDRS ID
	A = TDRS 1300
	B = TDRS 1301
	C = TDRS 1302
	D = TDRS 1303
	E = TDRS 1304
	F = TDRS 1305
	G = TDRS 1306
	H = TDRS 1307
	I = TDRS 1308
	J = TDRS 1309
3	

9.2.2.2 SHO Subheader No. 2: Service Start and Stop - Date and Time

# of Bytes	Data Item
	Start:
2	Year
3	Day
2	Hours
2	Minutes
2	Seconds

# of Bytes	Data Item
	Stop:
2	Year
3	Day
2	Hours
2	Minutes
2	Seconds
22	

9.2.2.3 SHO Subheader No. 3: Service Configuration

# of Bytes	Data Item
1	Service Configuration 1 = Normal KSA/KaSA or SSA only (DG1 or DG2) (Shuttle unique parameters are set to ASCII space) 2 = Shuttle KSA or Shuttle SSA service only (Normal user unique parameters are set to ASCII space) 3 = SSA Service to MA/SMA user* 4 = Spare 5 = Spare 6 = Spare 7 = Spare

* - Equivalent to Data Item 1.

9.2.2.4 SHO Subheader No. 4: Configuration, Data Coding, and Modulation

# of Bytes	Data Item
1	DG1 Configuration - Normal User
	0 = I channel only (BPSK)
	1 = Q channel only (BPSK)
	2 = I and Q channel (QPSK)
1	Data Coding (DG1/DG2) - I Channel - Normal User
	0 = Uncoded
	1 = Code 1 (Rate 1/2)
	2 = Code 2 (Rate 1/2)
	3 = Code 3 (Rate 1/3)
1	Data Coding (DG1/DG2) - Q Channel - Normal User
	0 = Uncoded
	1 = Code 1 (Rate 1/2)
	2 = Code 2 (Rate 1/2)
	3 = Code 3 (Rate 1/3)
3	Spare
6	

9.2.2.5 SHO Subheader No. 5: DIS Receive Parameters

# of Bytes	Data Item
	SHO Subheader Designation
1	5 or "N" for not applicable. If "N", this channel is not reconfigurable.
	DIS Enable Time
2	Year
3	Day
2	Hours
2	Minutes
2	Seconds

# of Bytes	Data Item
	DIS Disable Time
2	Year
3	Day
2	Hours
2	Minutes
2	Seconds
1	Data Source (the following parameters in Subheader No. 5 are for control of the designated Demultiplexer (DEMUX)).
	1 = GSFC Demux
	2 = JSC Demux
	3 = Local Interface (LI)
1	LI
	1-4 = Channel I.D.
	0 = not LI
2	Port Address*
	4 Hexadecimal characters
1	Blocked/Unblocked Data*
	1 = Blocked
	2 = Unblocked
1	Clamped/Unclamped Clock*
	1 = Clamped
	0 = Unclamped
1	Clock Tracking* **
	1 = Yes
	0 = No

* Applicable to MDM only.

** The clock tracking parameter for DEMUX configuration shall not be used for Shuttle Forward Data or for any End-to-End Test user return data.

# of Bytes	Data Item
1	Circuit Assurance Block (CAB)*
	1 = Yes
	0 = No
6	Data Rate (bps)**
	Five most significant decimal digits and single decimal digit exponent. Digits are left justified. Decimal point is assumed to be between first and second digits.
36	Spare
73	

9.2.2.6 SHO Subheader No. 6: DIS Transmit Parameters

# of Bytes	Data Item
1	SHO Subheader Designation 6 or "N" for not applicable. If "N", this channel is not reconfigurable.
	I-Channel
	DIS Enable Time
2	Year
3	Day
2	Hours
2	Minutes
2	Seconds
	DIS Disable Time
2	Year
3	Day

* Applicable to MDM only.
** A valid data rate is required to configure a DIS data path for all Data sources. A zero data rate shall indicate that a DIS data path shall not be configured for this channel, but the channel may be reconfigured.

# of Bytes	Data Item
2	Hours
2	Minutes
2	Seconds
1	Data Destination 1 = LI 2 = HDRM 3 = MDM 4 = Record Only 5 = Television (TV) - Shuttle Only 6 = Analog Data - Shuttle Only
1	LI 1-4 Channel I.D. 100 BPS $\leq$ Data Rate $\leq$ 10 MBPS 5-8 Channel I.D. 10 MBPS < Data Rate $\leq$ 300 MBPS 0 = not LI If Data rate is $\geq$ 150 MBPS, 5-8 specifies the service, i.e., no Q-Channel specified.
1	HDRM 0 = Not used 1-4 Input Port Number If non-zero and SHO Class = 6, this is the HDRM input port for data which is received on the same High Data Rate Demultiplexer (HDRD) port. When SHO Class = 6 the SHO will contain only the SHO Header and Subheader 6. The same HDRM input ports at STGT and WSGTU shall not be simultaneously scheduled. A SHO Class 6 shall be sent to WSGTU whenever the HDRM at STGT is scheduled.
2	Port Address* 4 Hexadecimal Characters

* Applicable to MDM only.

# of Bytes	Data Item
1	Blocked/Unblocked Data* 1 = Blocked 0 = Unblocked
1	Data Stream I.D.* 2 Hexadecimal characters for 8 bit I.D.
1	Timeout* 1 = Yes 2 = No
1	Modifying/Unmodifying Header* 1 = Modify 2 = Unmodify
1	Time Tag* 1 = Yes 0 = No
6	Data Rate (bps)** Five most significant decimal digits and single decimal digit exponent. Digits are left justified. Decimal point is assumed to be between the first and second digits.
31	Spare
70(n)	

Where:
n = 2 For QPSK, BPSK, or Shuttle S-Band
n = 3 For Shuttle K-Band

Q-Channel
Repeat 70 bytes for Q-Channel (n = 2).
For Shuttle S-Band I Channel is applicable,
Q Channel is not applicable (N). For Shuttle
K-Band repeat 70 bytes for Channels 1, 2 and 3 (n = 3).
When repeats are not applicable, the first byte shall be
"N" and remaining bytes ASCII Space.

*Applicable to MDM only.

** For Shuttle K-Band Mode 2 Channel 3 this field is either:
a. Data rate for digital data from 16 Kbps to 4 Mbps,
b. Data rate for 1.024 Mhz subcarrier; 1,2,4,8 or 16 Kbps, or
c. Not applicable if Data Destination is 5 or 6.
For Shuttle K-Band Channel 2 this field is either:
a. Data rate for digital data from 16 Kbps to 2 Mbps, or
b. Data rate for 1.024 Mhz subcarrier: 1,2,4,8 or 16 Kbps.

A valid data rate is required to configure a DIS data patch for Data Destinations 1,2,3, and 4. A zero data rate shall indicate that a DIS data path shall not be configured for this channel, but the channel may be reconfigured. For Data Destinations 5 and 6, the data rate shall be ASCII spaces and these destinations shall be reconfigurable.

9.2.3 SHO Services

9.2.3.1 MA/SMA Forward, Fixed Parameters

# of Bytes	Data Item
3	SHO Subheader No. 1
22	SHO Subheader No. 2
3	Spare
28	

9.2.3.2 MA/SMA Forward, Reconfigurable Parameters

# of Bytes	Data Item
73	SHO Subheader No. 5
1	User Despun Antenna 0 = No Type 1 = Type 1 2 = Type 2
9	Data Rate (LSD = 1 bps)
10	User Receive Frequency (LSD = 10 Hz)
1	Doppler Compensation Required 0 = No 1 = Yes
94	

9.2.3.3 SSA Forward, Fixed Parameters

# of Bytes	Data Item
3	SHO Subheader 1
22	SHO Subheader 2
1	SHO Subheader 3
1	Power Mode - Normal User 0 = Normal 1 = High

# of Bytes	Data Item
1	Power Mode - Shuttle 0 = Normal 1 = High
8	Shuttle PN Rate (LSD = 1 Chip/Second)
7	Spare
43	

9.2.3.4 SSA Forward, Reconfigurable Parameters

# of Bytes	Data Item
73	SHO Subheader No. 5
1	User Despun Antenna 0 = No Type 1 = Type 1 2 = Type 2
9	Data Rate, Normal User (LSD = 1 bps) Data rate for Shuttle specified by Shuttle configuration: Mode 1/Mode 2
10	Receive Frequency, Normal User (LSD = 10 Hz)
10	Receive Frequency, Shuttle (LSD = 10 Hz)
1	Polarization - Normal User 0 = LCP 1 = RCP
1	Polarization - Shuttle 0 = LCP 1 = RCP

# of Bytes	Data Item
1	Command Channel PN Modulation - Normal User 0 = No 1 = Yes
1	Doppler Compensation Required - Normal User 0 = No 1 = Yes
1	Shuttle Carrier Doppler Compensation 0 = No 1 = Yes
1	Shuttle PN Rate Doppler Compensation 0 = No 1 = Yes
1	Shuttle PN Modulation 0 = No 1 = Yes
1	Shuttle Configuration 1 = Mode 1 (32 Kbps) 2 = Mode 2 (72 Kbps)
111	

9.2.3.5 KSA/KaSA Forward, Fixed Parameters

# of Bytes	Data Item
3	SHO Subheader 1
22	SHO Subheader 2
1	SHO Subheader 3
1	Power Mode - Normal User 0 = Normal 1 = High
1	Power Mode - Shuttle 0 = Normal 1 = High
1	Spare
29	

9.2.3.6 KSA/KaSA Forward, Reconfigurable Parameters

# of Bytes	Data Item
73	SHO Subheader No. 5
9	Data Rate, Normal User (LSD = 1 bps)
9	Data Rate, Shuttle (LSD = 1 bps) Only two data rates are involved, 72 or 216 Kbps. All changes to Shuttle Data Rate are implemented via a reconfiguration OPM-3.
6	Spare
10	Receive Frequency, Normal User (LSD = 10 Hz)
10	Receive Frequency, Shuttle (LSD = 10 Hz)
1	Polarization - Normal User 0 = LCP 1 = RCP
1	Polarization - Shuttle 0 = LCP 1 = RCP
1	Command Channel PN Modulation - Normal User and Shuttle 0 = No 1 = Yes Note: Not applicable for data rates above 300 Kbps
1	Doppler Compensation Required, Normal User 0 = No 1 = Yes
1	Doppler Compensation Required, Shuttle 0 = No 1 = Yes
122	

9.2.3.7 MA Return, Fixed Parameters

# of Bytes	Data Item
3	SHO Subheader 1
22	SHO Subheader 2
1	Receiver Configuration 0 = Normal 1 = Cross-support
1	Symbol Format Conversion to BIϕ-L - I Channel 0 = No 1 = Yes
1	Symbol Format Conversion to BIϕ-L - Q Channel 0 = No 1 = Yes
6	Spare
2	MA Return Link ID (01-05)
1	Spare
1	Cross Support Forward Link 0 = MA 1 = SSA1 2 = SSA2
1	Configuration 0 = I Channel only 1 = Q Channel only 2 = I and Q Channel
1	Return Channel Time Delay Data Required 0 = No 1 = Yes
	Max Data Rate (LSD = 1 bps)
9	I Channel
9	Q Channel
58	

9.2.3.8 MA Return, Reconfigurable Parameters

# of Bytes	Data Item
140	SHO Subheader No. 6
1	User Despun Antenna 0 = No Type 1 = Type 1 2 = Type 2
	Data Rate (LSD = 1 bps) (Note: Zero Value denotes no data on channel)
9	I Channel
9	Q Channel
10	User Transmit Frequency (LSD = 10 Hz)
4	Maximum EIRP Sign, 3 Digits (LSD = 0.1 dBw)
4	Minimum EIRP Sign, 3 Digits (LSD = 0.1 dBw)
3	I/Q Channel Power Ratio Sign, 2 Digits (LSD = 0.1 dB)
1	Data Format for I Channel 0 = NRZ-L 1 = NRZ-M 2 = NRZ-S
1	Data Format for Q Channel 0 = NRZ-L 1 = NRZ-M 2 = NRZ-S
1	Data Bit Jitter for I Channel 0 = None 1 = 0.01% 2 = 0.1%

# of Bytes	Data Item
1	Data Bit Jitter for Q Channel 0 = None 1 = 0.01% 2 = 0.1%
1	G2 Inversion - I Channel 0 = G2 polynomial normal 1 = G2 polynomial inverted
1	G2 Inversion - Q Channel 0 = G2 polynomial normal 1 = G2 polynomial inverted
1	Mode 1 = Mode 1 - Coherent 2 = Mode 2 - Noncoherent
1	Spare
1	Data Channel Configuration 0 = Single Data Source 1 = Dual Data Source
5	Frame Length - I Channel* (32000 bits maximum)
2	Frame Sync Word Length - I Channel (32 bits maximum)
4	Frame Sync Word Bit Pattern - I Channel (8 hexadecimal digits - left justified)
5	Sync Strategy Parameters - I Channel** N_1, N_2, N_3, N_4, N_5
5	Frame Length - Q Channel* (32000 bits maximum)
2	Frame Sync Word Length - Q Channel (32 bits maximum)
4	Frame Sync Word Bit Pattern - Q Channel (8 hexadecimal digits- left justified)
5	Sync Strategy Parameters - Q Channel** N_1, N_2, N_3, N_4, N_5
221	

* Note: Frame Length equal to zero indicates that Data Quality Monitor (DQM) is not required for this channel.

** The value of N3 will always be "1".

9.2.3.9 SSA/SMA Return, Fixed Parameters

# of Bytes	Data Item
3	SHO Subheader No. 1
22	SHO Subheader No. 2
1	SHO Subheader No. 3
6	SHO Subheader No. 4
9	Spare
1	Receiver Configuration - Normal User 0 = Normal 1 = Cross-support
	Symbol Format Conversion to BIϕ-L for DG1/DG2
1	I Channel - Normal User 0 = No 1 = Yes
1	Q Channel - Normal User 0 = No 1 = Yes
1	SSA Combining (ASCII blank for SMA service) 0 = No 1 = Yes
1	SMA Return Link ID (1-5) (note: ASCII blank for SSA service)
1	Cross Support Forward Link - Normal User 0 = MA 1 = SSA1 2 = SSA2 3 = SMA
1	Return Channel Time Delay Data Required 0 = No 1 = Yes
1	Spare
	Max Data Rate DG1/DG2 (LSD = 1 bps)
9	I Channel - Normal User
9	Q Channel - Normal User
67	

9.2.3.10 SSA/SMA Return, Reconfigurable Parameters

# of Bytes	Data Item
140	SHO Subheader No. 6
1	User Despun Antenna 0 = No Type 1 = Type 1 2 = Type 2
	Data Rate DG1/DG2 - Normal User (LSD = 1 bps) (Note: Zero value denotes no data on channel)
9	I Channel - Normal User
9	Q Channel - Normal User
10	Transmit Frequency - Normal User (LSD = 10 Hz)
1	Polarization - Normal User 0 = LCP 1 = RCP
1	Polarization - Shuttle 0 = LCP 1 = RCP
4	Maximum EIRP - Normal User Sign, 3 Digit (LSD = 0.1 dBw)
4	Minimum EIRP - Normal User Sign, 3 Digits (LSD = 0.1 dBw)
4	Maximum EIRP - Shuttle Sign, 3 Digits (LSD = 0.1 dBw)
4	Minimum EIRP - Shuttle Sign, 3 Digits (LSD = 0.1 dBw)
3	I/Q Channel Power Ratio (DG1/DG2) - Normal User Sign, 2 Digits (LSD = 0.1 dB)

# of Bytes	Data Item
1	Data Format for I Channel (DG1/DG2) - Normal User 0 = NRZ-L 1 = NRZ-M 2 = NRZ-S 3 = BIϕ-L 4 = BIϕ-M 5 = BIϕ-S
1	Data Format for Q Channel (DG1/DG2) - Normal User 0 = NRZ-L 1 = NRZ-M 2 = NRZ-S 3 = BIϕ-L 4 = BIϕ-M 5 = BIϕ-S
1	Data Bit Jitter for I Channel (DG1/DG2) - Normal User 0 = None 1 = 0.01% 2 = 0.1%
1	Data Bit Jitter for Q Channel (DG1/DG2) - Normal User 0 = None 1 = 0.01% 2 = 0.1%
1	Data Bit Jitter for Shuttle 0 = None 1 = 0.01% 2 = 0.1%
10	Shuttle Transmit Frequency if Noncoherent (LSD = 10 Hz) (Note: Must contain zero value if transmit frequency is coherent)
1	Data Group - Normal User 1 = Data Group 1 2 = Data Group 2
1	DG1 Mode - Normal User 1 = Mode 1 - Coherent 2 = Mode 2 - Noncoherent 3 = Mode 3 - Coherent with no Q channel deinterleaving 4 = Mode 3 - Coherent with Q channel deinterleaving

# of Bytes	Data Item
1	DG2 Type - Normal User 0 = Noncoherent with I and with Q channel deinterleaving 1 = Noncoherent with no I and no Q channel deinterleaving 2 = Coherent with no I and with no Q channel deinterleaving 3 = Coherent with I and Q channel deinterleaving 4 = Noncoherent with I and with no Q channel deinterleaving 5 = Noncoherent with no I and with Q channel deinterleaving 6 = Coherent with no I and with Q channel deinterleaving 7 = Coherent with I and with no Q channel deinterleaving
1	Shuttle Configuration 1 = Mode 1 2 = Mode 2 3 = Mode 3
1	G2 Inversion - I Channel - Normal User (See ground rule 29, Section 2.2.2.) 0 = G2 polynomial normal, - I leads Q, or G2 polynomial inverted and I lags Q 1 = G2 polynomial inverted - I leads Q, or G2 polynomial normal and I lags Q
1	G2 Inversion - Q Channel - Normal User 0 = G2 polynomial normal 1 = G2 polynomial inverted

# of Bytes	Data Item
1	Data Channel Configuration (DG1/DG2) - Normal User 0 = Single Data Source Identical coded data on I and Q Channels (DG1) G1 on I Channel, G2 on Q Channel (DG2) 1 = Dual Data Source 2 = Single Data Source G1 G2 (G3) of Alternate Data Bits on I G1 G2 (G3) of Alternate Data Bits on Q
1	DG2 Modulation - Normal User 0 = QPSK 1 = BPSK
5	Frame Length - I Channel* (32000 bits maximum)
2	Frame Sync Word Length - I Channel (32 bits maximum)
4	Frame Sync Word Bit Pattern - I Channel (8 hexadecimal digits - left justified)
5	Sync Strategy Parameters - I Channel** N_1, N_2, N_3, N_4, N_5
5	Frame Length - Q Channel - Normal User* (32000 bits maximum)
2	Frame Sync Word Length - Q Channel - Normal User (32 bits maximum)
4	Frame Sync Word Bit Pattern - Q Channel - Normal User (8 hexadecimal digits - left justified)
5	Sync Strategy Parameters - Q Channel - Normal User** N_1, N_2, N_3, N_4, N_5
245	

* Note: Frame Length equal to zero indicates that DQM is not required on this channel. For single data source with alternate bits on the I and Q channels, the I Channel DQM parameters are applicable. The I Channel DQM parameters are also used for Shuttle.

** The value of N3 will always be "1".

9.2.3.11 KSA/KaSA Return, Fixed Parameters

# of Bytes	Data Item
3	SHO Subheader No. 1
22	SHO Subheader No. 2
1	SHO Subheader No. 3
6	SHO Subheader No. 4
	Symbol Format Conversion to BIϕ-L for DG1/DG2
1	I Channel - Normal User 0 = No 1 = Yes
1	Q Channel - Normal User 0 = No 1 = Yes
1	Return Channel Time Delay Data Requested 0 = No 1 = Yes
1	Spare
	Max Data Rate (LSD = 1 bps)*
9	I Channel (or Shuttle Channel 1)
9	Q Channel (or Shuttle Channel 2)
9	Shuttle Channel 3
63	

* For users requiring autotrack, the Max Data Rate for one of the channels must be greater than or equal to 2.14 Mbps.

9.2.3.12 KSA/KaSA Return, Reconfigurable Parameters

# of Bytes	Data Item
210	SHO Subheader No. 6
6	Spare
	Data Rate DG1/DG2 - Normal User (LSD = 1 bps) (Note: Zero value denotes no data on channel)
9	I Channel - Normal User
9	Q Channel - Normal User
10	Transmit Frequency, Normal User (LSD = 10 Hz)
1	Polarization, Normal User 0 = LCP 1 = RCP
1	Polarization, Shuttle 0 = LCP 1 = RCP
4	Maximum EIRP, Normal User Sign, 3 Digits (LSD = 0.1 dBw)
4	Minimum EIRP, Normal User Sign, 3 Digits (LSD = 0.1 dBw)
4	Maximum EIRP, Shuttle Sign, 3 Digits (LSD = 0.1 dBw)
4	Minimum EIRP, Shuttle Sign, 3 Digits (LSD = 0.1 dBw)

# of Bytes	Data Item
8	Autotrack Enable/Disable 00000000 = Enable 00000001 = Disable
3	I/Q Channel Power Ratio - Normal User Sign, 2 Digits (LSD = 0.1 dB)
1	Data Format for I Channel (DG1/DG2) - Normal User 0 = NRZ-L 1 = NRZ-M 2 = NRZ-S 3 = BIϕ-L 4 = BIϕ-M 5 = BIϕ-S
1	Data Format for Q Channel (DG1/DG2) - Normal User 0 = NRZ-L 1 = NRZ-M 2 = NRZ-S 3 = BIϕ-L 4 = BIϕ-M 5 = BIϕ-S
1	Data Bit Jitter for I Channel (DG1/DG2) - Normal User 0 = None 1 = 0.01% 2 = 0.1%
1	Data Bit Jitter for Q Channel (DG1/DG2) - Normal User 0 = None 1 = 0.01% 2 = 0.1%
10	Shuttle Transmit Frequency (LSD = 10 Hz)
1	Data Group - Normal User 1 = Data Group 1 2 = Data Group 2

# of Bytes	Data Item
1	DG1 Mode - Normal User 1 = Mode 1 - Coherent 2 = Mode 2 - Noncoherent 3 = Mode 3 - Coherent
1	DG2 Type - Normal User 1 = Noncoherent 2 = Coherent
1	Shuttle Mode 1 = Mode 1 2 = Mode 2, Channel 3 Digital 3 = Mode 2, Channel 3 Analog 4 = Mode 2, Channel 3 TV
1	Data Format, Channel 1 (Mode 1 or 2) - Shuttle 3 = BIϕ-L
1	Data Bit Jitter, Channel 1 (Mode 1 or 2) - Shuttle 0 = None 1 = 0.01% 2 = 0.1%
1	Data Format, Channel 2 (Mode 1 or 2) - Shuttle* 0 = NRZ-L 1 = NRZ-M 2 = NRZ-S 3 = BIϕ-L 4 = BIϕ-M 5 = BIϕ-S

* In Mode 2, simultaneous support of digital data on Channel 3 and the 1.024 MHz subcarrier on Channel 2 is not required.

# of Bytes	Data Item
1	Data Bit Jitter, Channel 2 (Mode 1 or 2) - Shuttle
	0 = None
	1 = 0.01%
	2 = 0.1%
	3 = 0.5%
	4 = 1.0%
	5 = 2.0%
9	Data Rate, Channel 2 (Mode 1 or 2) (LSD = 1 bps) - Shuttle
1	Data Format, Channel 3, (Mode 1 or 2) - Shuttle*
	0 = NRZ-L
	1 = NRZ-M
	2 = NRZ-S
	3 = BIϕ-L
	4 = BIϕ-M } only for Channel 3, Mode 2
	5 = BIϕ-S
1	Data Bit Jitter, Channel 3, (Mode 1 or 2) - Shuttle**
	0 = None
	1 = 0.01%
	2 = 0.1%
9	Data Rate, Channel 3 (Mode 1 or 2) (LSD = 1 bps) - Shuttle
1	Shuttle 1.024-MHz Subcarrier
	1 = Not used
	2 = Channel 2
	3 = Channel 3
8	Spare

* In Mode 2, simultaneous support of digital data on Channel 3 and the 1.024 MHz subcarrier on Channel 2 is not required.

** In Mode 2, not applicable only for the 1.024 MHz subcarrier.

# of Bytes	Data Item
1	G2 Inversion - I Channel - Normal User (See ground rule 29, Section 2.2.2) 0 = G2 polynomial normal - I leads Q, or G2 polynomial inverted and I lags Q 1 = G2 polynomial inverted - I leads Q, or G2 polynomial normal and I lags Q
1	G2 Inversion - Q Channel - Normal User 0 = G2 polynomial normal 1 = G2 polynomial inverted
1	Data Channel Configuration - Normal User 0 = Single Data Source 1 = Dual Data Source
1	DG2 Modulation - Normal User 0 = QPSK 1 = BPSK
5	Frame Length - I Channel or Channel 1* (32000 bits maximum)
2	Frame Sync Word Length - I Channel or Channel 1 (32 bits maximum)
4	Frame Sync Word Bit Pattern - I Channel or Channel 1 (8 hexadecimal digits - left justified)
5	Sync Strategy Parameters - I Channel or Channel 1** N_1, N_2, N_3, N_4, N_5
5	Frame Length - Q Channel or Channel 2* (32000 bits maximum)
2	Frame Sync Word Length - Q Channel or Channel 2 (32 bits maximum)
4	Frame Sync Word Bit Pattern - Q Channel or Channel 2 (8 hexadecimal digits - left justified)

* Frame length equal to zero indicates that DQM is not required for this channel. For single data source with alternate bits on the I and Q channels, the I Channel DQM parameters are applicable.

** The value of N3 will always be "1".

# of Bytes	Data Item
5	Sync Strategy Parameters - Q Channel or Channel 2* N_1, N_2, N_3, N_4, N_5
5	Frame Length - Channel 3 - Shuttle** (32000 bits maximum)
2	Frame Sync Word Length - Channel 3 - Shuttle (32 bits maximum)
4	Frame Sync Word Bit Pattern - Channel 3 - Shuttle (8 hexidecimal digits - left justified)
5	Sync Strategy Parameters - Channel 3 - Shuttle* N_1, N_2, N_3, N_4, N_5
376	

9.2.3.13 Tracking, Normal and Time Transfer

# of Bytes	Data Item
3	SHO Subheader No. 1
22	SHO Subheader No. 2
1	Tracking Configuration => 0 = Normal 1 = Cross-Support
1	Normal Tracking 0 = MA 1 = SSA 2 = KSA 3 = Shuttle S-Band 4 = Shuttle Ku-Band 5 = SMA
1	Time Transfer Required 0 = No 1 = Yes

* The value of N3 will always be "1".

** Frame length equal to zero indicates that DQM is not required for this channel. For single data source with alternate bits on the I and Q channels, the I Channel DQM parameters are applicable.

# of Bytes	Data Item
1	Number of Time Transfer Samples (Binary, 20-255)*
1	Spare
1	Sample Rate (samples/second) 0 = 1/1 1 = 1/5 2 = 1/10 3 = 1/60 4 = 1/300
1	Range Tracking Required 0 = No 1 = Yes
1	Doppler Tracking Required 0 = Not Required 1 = One-way 2 = Two-way
10	Spare (ASCII "Blank")
2	MA/SMA Return Link ID (01 to 05) (Used to identify the specific MA/SMA Return service in the SHO. This field will be set to ASCII space if the Return service is not an MA/SMA Return.)
45	

9.2.3.14 Tracking, Cross-Support and Time Transfer

# of Bytes	Data Item
3	SHO Subheader No. 1
22	SHO Subheader No. 2

* Sample rate is 1/second. Sampling shall commence at start of tracking service.

# of Bytes	Data Item
1	Tracking Configuration 0 = Normal => 1 = Cross-Support
1	Cross-Support Tracking 0 = Range 1 = Two-way Doppler 2 = Both
1	Time Transfer Required 0 = No 1 = Yes
1	Number of Time Transfer Samples (Binary, 20-255)*
1	Spare
1	Sample Rate (samples/second) 0 = 1/1 1 = 1/5 2 = 1/10 3 = 1/60 4 = 1/300
1	Forward Link 0 = MA 1 = SSA1 2 = SSA2 3 = SMA
1	Return Link 0 = MA 1 = SSA1 2 = SSA2 3 = SMA
2	MA/SMA Return Link ID (01 to 05) (Used to identify the specific MA/SMA Return service in the SHO. This field will be set to ASCII space if the Return service is not an MA/SMA Return.)
35	

* Sample rate is 1/second. Sampling shall commence at start of tracking service.

9.2.3.15 End-to-End Test Data Set (See 9.2.3.17 for End-to-End Test SHO Structure)

9.2.3.15.1 Forward Data

# of Bytes	Data Item
3	SHO Subheader No. 1
22	SHO Subheader No. 2
70	SHO Subheader No. 6**
4	Spare
4	G/T of Simulated User (LSD = $\pm$ 0.1 dB/°K)
1	Local or DIS Data* 0 = Local 1 = DIS
10	Spare
114	

* If data is locally generated (0 = Local), Subheaders 5 and 6 are not applicable and the SHO Subheader Designation Parameters shall be set to ASCII “N”.

** SHO Subheader 6 shall specify the return path for the forward user data.

9.2.3.15.2 Return Data

# of Bytes	Data Item
3	SHO Subheader No. 1
22	SHO Subheader No. 2
146	SHO Subheader No. 5***
4	EIRP of Simulated User (LSD = ± 0.1 dBw)
4	Spare
1	Local or DIS Data* 0 = Local 1 = DIS
10	Spare
190	

* If data is locally generated (0 = Local), Subheaders 5 and 6 are not applicable and the SHO Subheader Designation Parameters shall be set to ASCII “N”.

** Not used.

*** SHO Subheader 5 shall specify the forward path for the user return data.

9.2.3.16 Example of SHO Structure

Note that the Forward services precede the Return services, which in turn precede the tracking services. Note also that the maximum number of services in a SHO is 16; for example below: $i + j + k \leq 16$. The fixed parameters include applicable SHO subheaders.

Network Control Header	
TDRSS Header	
Time Field	
Acknowledgment Subfield	
SHO Header	
Forward No. 1	Fixed Parameters
	Reconfigurable Parameters
.	
.	
Forward No. i	Fixed Parameters
	Reconfigurable Parameters
Return No. 1	Fixed Parameters
	Reconfigurable Parameters
.	
.	
.	
Return No. j	Fixed Parameters
	Reconfigurable Parameters
Tracking No. 1 Data Set	
.	
.	
.	
.	
Tracking No. k Data Set	
Filler (as required)	
Error Control Field	

9.2.3.17 Example of an End-to-End Test SHO Structure

Note the placement of the End-to-End Test data sets. There must be a corresponding traffic service for each End-to-End Test service. This example shows three Forward and Return services with their End-to-End Test data sets. The SHO Subheader Designation Parameters in Subheaders 5 and 6 in the reconfigurable parameters of the forward and return data sets shall be set to ASCII "N" for all users except Shuttle, when in the local mode. For Shuttle and all users in the DIS mode there shall be legitimate parameters in all fields of the SHO Subheaders 5 and 6.

<table>
<tr><td colspan="2">Network Control Header</td></tr>
<tr><td colspan="2">TDRSS Header</td></tr>
<tr><td colspan="2">Time Field</td></tr>
<tr><td colspan="2">Acknowledgment Subfield</td></tr>
<tr><td colspan="2">SHO Header</td></tr>
<tr><td rowspan="2">Forward No. 1</td><td>Fixed Parameters</td></tr>
<tr><td>Reconfigurable Parameters</td></tr>
<tr><td colspan="2">End-to-End Test Data Set for Forward No. 1</td></tr>
<tr><td rowspan="2">Forward No. 2</td><td>Fixed Parameters</td></tr>
<tr><td>Reconfigurable Parameters</td></tr>
<tr><td colspan="2">End-to-End Test Data Set for Forward No. 2</td></tr>
<tr><td rowspan="2">Forward No. 3</td><td>Fixed Parameters</td></tr>
<tr><td>Reconfigurable Parameters</td></tr>
<tr><td colspan="2">End-to-End Test Data Set for Forward No. 3</td></tr>
<tr><td rowspan="2">Return No. 1</td><td>Fixed Parameters</td></tr>
<tr><td>Reconfigurable Parameters</td></tr>
<tr><td colspan="2">End-to-End Test Data Set for Return No. 1</td></tr>
<tr><td rowspan="2">Return No. 2</td><td>Fixed Parameters</td></tr>
<tr><td>Reconfigurable Parameters</td></tr>
<tr><td colspan="2">End-to-End Test Data Set for Return No. 2</td></tr>
<tr><td rowspan="2">Return No. 3</td><td>Fixed Parameters</td></tr>
<tr><td>Reconfigurable Parameters</td></tr>
<tr><td colspan="2">End-to-End Test Data Set for Return No. 3</td></tr>
<tr><td colspan="2">Tracking Data Set No. 1</td></tr>
<tr><td colspan="2">Tracking Data Set No. 2</td></tr>
<tr><td colspan="2">Tracking Data Set No. 3</td></tr>
<tr><td colspan="2">Filler (as required)</td></tr>
<tr><td colspan="2">Error Control Field</td></tr>
</table>

Note: In End-to-End Test SHOs the specified PN code shall be ignored. The following PN codes shall be used for End-to-End Test at STGT:

Service	PN Code
Multiple Access (MA)/S-Band MA (SMA)*	39
S-Band Single Access (SSA)	40
K-Band Single Access (KSA)	41
K-Band Shuttle (KSH)	42
S-Band Shuttle (SSH)	3

* Each TDRS will provide either MA or SMA services but not both, thus only one PN code is required. (See STDN 108 for more details on PN code).

9.3 Message Subfield for OPM's

Within a 4800-bit data block, the data subfield starts at byte 23. For OPM's, bytes 23 through 34 contain the OPM Data Header, made up of the message type (OPM = 03) and the OPM identity (ID), source, and class. The remainder of the OPM is made up of a combination of data items, depending upon the class of the OPM. OPM's may be of variable message length (1 to 15 4800-bit data blocks) to accommodate special instruction textual messages.

9.3.1 OPM Header

The structure of the OPM header is:

Byte #	# of Bytes	Data Item
23-24	2	Message Type 1 = Tracking Data 2 = SHO - Routine => 3 = OPM (Operations Messages) 4 = SLR (TDRSS Service Level Status) 5 = ODM (SA/SMAR Operations Data) 6 = ODM (MA/SMAF Operations Data) 7 = ODM (End-to-End Test Data) 8 = SHO - Periodic
25-31	7	OPM ID The ID is a seven-digit number. OPM's shall be sequentially numbered: 1 to 9,999,999 to 1

Byte #	# of Bytes	Data Item
32	1	OPM Source 0 = NASA - NCC 1 = TDRSS - TOCC2
33-34	2	OPM Class Paragraph 9.3.1.1 provides a list of OPM's by class code, referenced to sections following which provide specific information.
	12	

9.3.1.1 OPM's by Class

Reference Paragraph	Class Code:	Description
9.3.3		NCC OPM's
9.3.3.1	01	Special Instruction or Request
9.3.3.2	02	Reacquisition Request
9.3.3.3	03	Reconfiguration Request
9.3.3.4	04	Forward Link Sweep Request
9.3.3.5	05	Deleted
9.3.3.6	06	Forward Link EIRP Reconfiguration Request
9.3.3.7	07	Expanded User Frequency Uncertainty Request
9.3.3.8	08	Deleted
9.3.3.9	09	Test Message
9.3.3.10	10	Spacecraft State Vector
9.3.3.11	11	Doppler Compensation Inhibit Request
9.3.3.12	12	Cancel SHO Request
9.3.3.13	13	TDRS Maneuver Approval
9.3.3.14	14	Acknowledgment of Message Received
9.3.3.15	15	Emergency Spacecraft State Vector

Reference Paragraph	Class Code:	Description
9.3.3.16	16	Deleted
9.3.3.17	17	Deleted
9.3.3.18	18	Delta-T Adjustment

Note: For a given user, consecutive OPMs requiring reconfiguration of support equipment shall not be sent to the STGT until (1) receipt of an OPM-62 for the previous OPM or (2) expiration of the maximum time to complete the action of the previous OPM. Note that OPM's for different users may arrive at the maximum line rate. If, for instance, multiple OPM's for different MA users on the same SGLT arrive consecutively, they shall be processed in order of arrival, with each OPM allowed its specified implementation period.

Note: OPM class codes 19 through 50 not used.

Reference Paragraph	Class Code:	Description
9.3.4		STGT OPM's:
9.3.4.1	51	SHO Status
9.3.4.2	52	Return Channel Time Delay
9.3.4.3	53	Preventive Maintenance (PM) Request
9.3.4.4	54	Special Request or Information
9.3.4.5	57	Service Terminated
9.3.4.6	59	TDRS Maneuver Request
9.3.4.7	60	Acknowledgment of Message Received
9.3.4.8	61	Spacecraft State Vector Rejection
9.3.4.9	62	OPM Status
9.3.4.10	63	Acquisition Failure Notification
9.3.4.11	64	Real-Time Mode
9.3.4.12	65	Delta-T Adjustment Rejection
9.3.4.13	66	Time Transfer
9.3.4.14	67	Stationkeeping/Momentum Dump Data

Note: OPM class codes 68 through 99 not used.

9.3.2 OPM Subheader

An OPM subheader is used when it is necessary to refer to a specific SHO (and service within that SHO) to complete the function of the OPM. This subheader, when used, follows immediately after the OPM header in byte positions 35 through 45 of a 4800-bit data block. This subheader structure and code is:

# of Bytes	Data Item
7	SHO ID
1	TDRS ID: A = TDRS 1300 B = TDRS 1301 C = TDRS 1302 D = TDRS 1303 E = TDRS 1304 F = TDRS 1305 G = TDRS 1306 H = TDRS 1307 I = TDRS 1308 J = TDRS 1309
1	Service Support Subtype 0 = MA 1 = SSA1 2 = SSA2 3 = KSA1 4 = KSA2 5 = SMA 6 = KaSA1 7 = KaSA2
2	MA/SMA Return Link ID (01-05) (Used to identify the specific MA/SMA Return service in the SHO. This field will be set to ASCII space if the service is not an MA/SMA Return.)
11	

9.3.3 NCC OPM's

9.3.3.1 Special Instruction or Requests, OPM - Class 01

This message shall be used to send free-form alphanumeric text from the NCC to STGT. The STGT shall print this message and display it on a TOCC2 console. Only a TOCC2 operator uses this message; it is not used in automatic processing/control.

This OPM consists of one or more 4800-bit data blocks, the first of which contains an OPM header immediately followed by two bytes (35 and 36) which indicate the number of 4800-bit data blocks in the entire message. In any 4800-bit data block following this first one, the complete data subfield (bytes 23 through 596) may be used for alphanumeric text.

# of Bytes	Data Item
12	OPM Header
2	Number of 4800-bit data blocks
Variable	Free-form text field. The character set for free-form text messages is provided in Section 13.

9.3.3.2 Reacquisition Request, OPM - Class 02

The NCC shall send this message to STGT to initiate a reacquisition. Within 10 seconds of receipt of the return acquisition message and within 20 seconds of receipt of the forward reacquisition message, STGT shall complete the specified reacquisition procedure. This message structure is:

# of Bytes	Data Item
12	OPM Header
11	OPM Subheader
1	Service Support Type: 0 = Forward 1 = Return
24	

9.3.3.3 User Reconfiguration, OPM - Class 03

In the event of a need to reconfigure equipment supporting a User spacecraft, the NCC will transmit a User reconfiguration message. STGT reconfiguration shall be completed within 35 seconds of receipt of the User reconfiguration message. User reconfiguration OPM’s shall be used to accomplish the following functions:

a. Change mode of operation for DG1,

b. Change in data rate, data format, data bit jitter,

c. Initiation or termination of DG1 operation,

d. Initiation or termination of DG2 operation,

e. Initiation or termination of the command channel PN code,

f. Reinitiation of Forward link carrier Doppler compensation,

g. Reinitiation of Shuttle PN rate Doppler compensation,

h. Change in Forward and/or Return link carrier frequency,

i. Change of polarization,

j. Change in Shuttle S-Band carrier frequency,

k. Change in Shuttle S-Band Return link mode,

l. Initiation or termination of Shuttle coherent carrier turnaround,

m. Initiation or termination of PN for Shuttle S-Band Forward link,

n. Change in Shuttle Ku-Band mode of operation,

o. Initiation or termination of PN for Shuttle Ku-Band command channel,

p. Redefinition of maximum and minimum user EIRP (difference will not exceed 12 dB),

q. Redefinition of I-channel/Q-channel power ratio,

r. Initiation, termination, or type change of user despun antenna,

s. Initiation or termination of symbol interleaving,

t. Change from/to single or dual data source,

u. Change from/to QPSK or BPSK,

v. Autotrack enable/disable,

w. DQM Parameters, and

x. DIS Parameters in Subheaders 5 and 6.

   (Note: If a SHO Subheader 5 or 6 is marked with a "5" or "6", the same corresponding channel Subheader 5 or 6 in OPM 3 must also always be marked with a "5" or "6". The same is true for an "N" in the Subheader 5 or 6.)

For reference, the related SHO ID is contained in the OPM subheader.

The message structure is:

# of Bytes	Data Item
12	OPM Header
11	OPM Subheader
1	Service Support Type: 0 = Forward 1 = Return 2 = Forward End-to-End Test 3 = Return End-to-End Test

Variable Forward or Return Link Reconfigurable Parameters*

* For a Forward service, data items are added according to 9.2.3.2, 9.2.3.4 or 9.2.3.6 and SHO Subheader No. 6 of 9.2.3.15.1 for Forward End-to-End Test. For a Return service, data items are added according to 9.2.3.8, 9.2.3.10, or 9.2.3.12 and SHO Subheader No. 5 of 9.2.3.15.2 for Return End-to-End Test. Reconfigurable parameter fields which contain ASCII Blanks will be considered "no change" from the current user equipment configuration.

9.3.3.4 Forward Link Sweep Request, OPM - Class 04

In the event of the inability to accurately define f_o for a user spacecraft resulting in a need to sweep the Forward link carrier frequency, the NCC will send this message. A Forward link sweep shall not impact simultaneous Doppler compensation of f_o as scheduled by the NCC. The Forward Link Sweep Request shall not be required for Shuttle S-band. Initiation of a Forward Link Sweep shall be completed within 10 seconds of receipt of this message. The message structure is:

# of Bytes	Data Item
12	OPM Header
11	OPM Subheader
23	

9.3.3.5 Deleted

9.3.3.6 Forward Link EIRP Reconfiguration Request, OPM - Class 06

This OPM is used to set the SSA and KaSA/KSA EIRP to normal or high power. The TDRS shall complete this configuration within 10 seconds of receipt of this message. The message structure is:

# of Bytes	Data Item
12	OPM Header
11	OPM Subheader
1	Power Mode: 0 = Normal 1 = High
24	

9.3.3.7 Expanded User Frequency Uncertainty Request, OPM - Class 07

If it is not possible to accurately predict the user transmit frequency for DG1, Mode 2, and DG2 (noncoherent turnaround), the NCC will transmit to the STGT an expanded user frequency uncertainty request. The TDRS shall complete the reconfiguration to accommodate the user transmit frequency uncertainty within 5 seconds of receipt of the request. An OPM-07 for a coherent service will be rejected with a Problem Code 8 in OPM-62. This OPM, when received and accepted, shall remain in effect for the remainder of the applicable service during reacquisition.

# of Bytes	Data Item
12	OPM Header
11	OPM Subheader
23	

9.3.3.8 Deleted

9.3.3.9 Test Message, OPM - Class 09

The NCC shall use this message to determine the availability of the NCC/STGT communication channel. The acknowledge bit will be set. No processing other than acknowledgment is required. The STGT Source/Destination code shall be used.

# of Bytes	Data Item
12	OPM Header

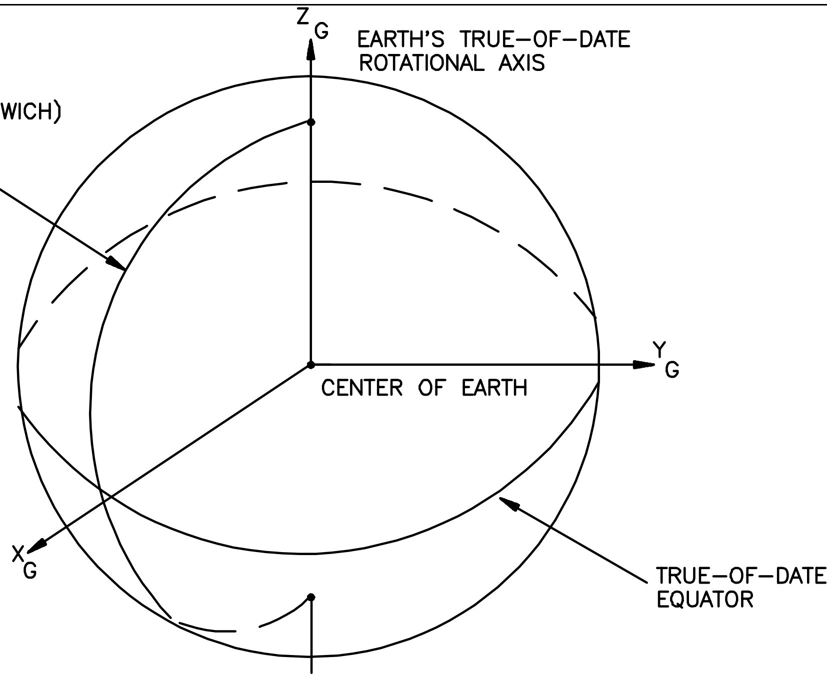
9.3.3.10 Spacecraft State Vector, OPM - Class 10

The NCC shall use this message to send TDRS and user spacecraft state vectors to the STGT. The message format used is a subset of the improved interrange vector (IIRV).

The Greenwich true-of-date coordinate system, as shown in Figure 9-1 shall be used as the coordinate system for all the NCC provided state vectors. The STGT shall perform the necessary transformation from the NASA specified coordinate system to the coordinate system used at the STGT.

The vehicle force model data consists of the user mass, and user average cross-sectional area. This data is received as part of the user state vector but is not applicable at STGT.

This space is intentionally left blank.



Name:	Greenwich True-of-Date (Geographic) Coordinate System
Origin:	The Center of the Earth
Orientation:	The X_G-Y_G plane is the earth's True-of-Date Equator The Z_G axis is directed along the earth's True-of-Date rotational axis and is positive north The $+X_G$ axis is directed toward the prime meridian The Y_G axis completes a right-handed system
Characteristics:	Rotating, right-handed, Cartesian. Velocity vectors expressed in this system are relative to a rotating reference frame fixed to the earth, whose rotation rates are expressed relative to the mean equator and equinox of 1950 system. True-of-date Greenwich implies reference to the instantaneous position of the equator and meridian, not reference to an equator of a nearby epoch date. NASA equations for rotation rate of the earth* shall be used in relating spacecraft positions in True-of-Date coordinates to an inertial system for integration.

* J. O. Cappellari, C. E. Velez, and A. J. Fuchs, "Mathematical Theory of the Goddard Trajectory Determination System," April 1976, GSFC x-582-76-77.

Figure 9-1. Greenwich True-Of-Date (Geographic) Coordinate System

The User spacecraft ephemerides are defined to be a series of state vectors. Ephemerides are differentiated from state vectors by vector type.

The data items marked with an asterisk(*) are included in this message structure in order to conform to the IIRV message format. STGT is not required and does not use these data items.

# of Bytes	Data Item
12	OPM Header
	Start of State Vector Data
1	G
1	I
1	I
1	R
1	V
1	Delete character*
4	Destination ID (Assigned by NASA)*
2	Carriage return*
2	Line feed*
1	Vector Type: 1 = Free Flight 2 = Transition to Free Flight 3 = Not Used 4 = Ignition 5 = Burnout** 6 = Reentry 7 = Launch or on-orbit 8 = Stationary (a ground-based User, including Null location)
1	Source of data:* 1 = Type 1 2 = Type 2 3 = Type 3

Fixed Code

* See last textual paragraph of 9.3.3.10.
** The type 5 vector is the last vector in an unstable sequence.

# of Bytes	Data Item
1	Transfer type (Fixed - set to "one")*
1	Coordinate system (Fixed - set to "one")*
4	User ID, Support Identification Code (SIC), assigned by NASA
2	User ID, Vehicle Identification Code (VIC), assigned by NASA Note: The combination of SIC and VIC will be unique for each user.
3	Vector Count*
	Time:
3	Day
2	Hour
2	Minute
5	Second (to 1 millisecond)
3	Checksum The contents of this field will be the arithmetic sum of bytes 49-73. In the arithmetic sum, the sign character (byte 52) is interpreted as a 1 for a minus character and a 0 for a space character.
2	Carriage Return*
2	Line Feed*
	Components of Position:
13	X
13	Y
13	Z

* See last textual paragraph of 9.3.3.10.

# of Bytes	Data Item
	The contents of these fields will be the X,Y, and Z components, respectively, of position in meters resolved to one meter. The most significant byte will be the polarity indicator for each component. The minus character in these bytes will indicate a negative quantity, whereas the space character will indicate a positive quantity.
3	Checksum The contents of this field will be the arithmetic sum of bytes for X, Y, and Z. In the arithmetic sum, the sign byte is interpreted as a 1 for minus character and a 0 for a space character.
2	Carriage Return*
2	Line Feed*
	Components of Velocity:
13	$\dot{X}$
13	$\dot{Y}$
13	$\dot{Z}$ The contents of these fields will be the $\dot{X}$, $\dot{Y}$, and $\dot{Z}$ components, respectively, of velocity in meters/second resolved to one thousandth meter/second. The most significant byte will be the polarity indicator for each component, and are defined the same as the position components above.

* See last textual paragraph of 9.3.3.10.

# of Bytes	Data Item
3	Checksum The contents of this field will be the arithmetic sum of $\dot{X}$, $\dot{Y}$, and $\dot{Z}$ and is defined the same as the previous checksum.
2	Carriage Return*
2	Line Feed*
8	User Mass* The contents of this field will be the mass of the user spacecraft in kilograms resolved to one tenth of a kilogram. The contents of this field will be zero when NASA requires that the solar radiation forces not be used for user orbit prediction.
5	User Average Cross-sectional Area* The contents of this field will be the average cross-sectional area of the User spacecraft in meters squared resolved to one hundredth meter squared. The contents of this field will be zero when NASA requires that the solar radiation forces not be used for user orbit prediction.
4	Not applicable - Reserve for drag factor.* The User Mass and Average Cross-sectional Area apply to the user's force model.
8	Not applicable (Fixed - set to zeros)*
3	Checksum* The contents of this field will be the arithmetic sum of the bytes for the User Mass, and User Cross-sectional Area and the four bytes reserved for drag factor. In the arithmetic sum, the most significant sign byte is interpreted as a 1 for a minus character and a 0 for a space character.

* See last textual paragraph of 9.3.3.10.

# of Bytes	Data Item
2	Carriage Return*
2	Line Feed*
5	End of Message:*
	I T E R M — Fixed Code
1	Delete Character*
4	Origination ID*
2	Carriage Return*
2	Line Feed*
196	

Note: If this message is to contain a second (and third) state vector, the preceding data items are repeated in order, without the OPM Header.

184	Second State Vector
184	Third State Vector
564	

9.3.3.11 Doppler Compensation Inhibit Request, OPM - Class 11

Forward link Doppler compensation shall be terminated upon receipt of a Doppler compensation inhibit request from the NCC. Within 10 seconds from receipt of this Doppler Compensation Inhibit Request message, OPM - Class 11, a transition profile shall be initiated to slowly change the frequency from the compensate profile to an integer multiple of 221 Hz (S-Band) or 146.9 Hz (K-Band). Within an additional 10 seconds, the forward link frequency shall be fixed at a set value where it will remain throughout the remainder of the service unless Doppler compensation is re-enabled. When Doppler compensation is re-enabled via OPM-03, the re-enabling shall be interpreted as requiring a transition profile (analogous to the compensation inhibit profile) to slowly change the frequency from the fixed frequency to the applicable Doppler compensation profile. For Ka-Band the slow transition for Doppler Compensation Inhibit is not required, i.e., the fixed frequency shall be the frequency at receipt of the OPM-11.

* See last textual paragraph of 9.3.3.10.

NOTE

Forward link Doppler compensation may also be terminated by using a User Reconfiguration, OPM - Class 03, in which "Doppler Compensation Required" is set to "0 = No."

For Shuttle S-Band forward link service, Doppler compensation of the PN rate shall be terminated only upon receipt of a Doppler compensation inhibit request from the NCC.

The message format and fields in this Doppler compensation inhibit request OPM are defined as follows:

# of Bytes	Data Item
12	OPM Header
11	OPM Subheader
1	Doppler Compensation Inhibit 0 = Other than SSA Shuttle 1 = Carrier only (SSA Shuttle) 2 = PN rate only (SSA Shuttle) 3 = Both carrier and PN rate (SSA Shuttle)
24	

9.3.3.12 Cancel SHO Request, OPM - Class 12

This message is used to request cancellation of either an ongoing or pending SHO. The message structure is:

# of Bytes	Data Item
12	OPM Header
7	SHO ID
19	

9.3.3.13 TDRS Maneuver Approval, OPM - Class 13

As a result of a TDRS maneuver request message from the STGT, the NCC will transmit to STGT a message approving or denying the maneuver request. This message will be routed to the TOCC2 operator for action. The message structure is:

# of Bytes	Data Item
12	OPM Header
7	TDRS Maneuver Request, OPM ID
1	Approval Code: 0 = Approved 1 = Rejected
	New Start Time: The contents of this field provide a suggested TDRS maneuver start time that would be acceptable to NASA
2	Year
3	Day
2	Hour
2	Minute
2	Second
Variable	This is a free-form text field for comments

The character set for free-form text messages is provided in Section 13.

9.3.3.14 Acknowledgment of Message Received, OPM - Class 14

This message shall be sent to acknowledge receipt of a message. This message structure consists of only the OPM Message Header, since the "acknowledgment" subfield in the data subfield provides the ID of the message satisfactorily received.

# of Bytes	Data Item
12	OPM Header

9.3.3.15 Spacecraft Emergency State Vector, OPM - Class 15

The NCC shall use this message (or OPM-Class 10) to send emergency state vectors to STGT. This message structure is the same as that for the Spacecraft State Vector OPM - Class 10, except that the OPM class code in the OPM Header is 15.

9.3.3.16 Deleted

9.3.3.17 Deleted

9.3.3.18 Delta-T Adjustment, OPM - Class 18

This message shall be used by the NCC to adjust the epoch time within State Vectors. The structure of this message is:

# of Bytes	Data Item	
12	OPM Header	
4	User ID, Support Identification Code (SIC)	
2	User ID, Vehicle Identification Code (VIC)	
1	Sign 0 = Plus 1 = Minus	Delta-T
5	Time Period, LSD = 1 Second	
24		

9.3.4 STGT OPM's

9.3.4.1 SHO Status OPM - Class 51

This message shall be used to inform the NCC of the status of a SHO. The structure of this message is:

# of Bytes	Data Item
12	OPM Header
7	SHO ID
1	SHO Status Code: 0 = Accepted 1 = Rejected 2 = Problem at SHO start 3 = (Spare) 4 = Problem with processing User or TDRS trajectory at SHO start
7	Conflicting SHO ID

# of Bytes	Data Item
2	Problem Code: 0 = No error 1 = Constraint on Service Start Time/SHO Receipt Time violation 2 = Unrecognizable parameter 3 = Parameter out of range 4 = No user ephemeris* 5 = Visibility check failure* 6 = Schedule conflict** 7 = Ground Antenna for TDRS not specified or designated TDRS not active 8 = Equipment not available* 9 = Acceleration exceeded (0.05 km/sec^2)* 10 = No TDRS ephemeris* 11 = SHO directory table overflow 12 = Duplicate SHO ID* 13 = Invalid User Configuration 14 = STGT Software/Data Base Error 15 = Spare 16 = Altitude exceeded (40,000 km)* 17 = SHO duration too short or too long 18 = End-to-End Test SHO format error 19 = Spare
2	Service number within the SHO (1-16) (Note: A zero value denotes the problem is not related to a specific service.)
31	

* Will not cause SHO to be rejected. At SHO receipt, Status Code 0 will be used with Problem Codes 4, 10 and 12. Six minutes prior to SHO start, Status Code 2 will be used with Problem Code 8 and Status Code 4 will be used with Problem Codes 4,5,9,10, and 16. In the case of Problem Codes 5,9, and 16, SHO support will be provided. Problem Code 8 is used only when there is no equipment available at start of service. Problem Code 12 indicates SHO received with duplicate I.D. was not processed. SHO support of existing SHO will be provided.

** If Problem Code 6 indicates a conflict with an ongoing Pseudo SHO, the conflicting SHO ID will be ASCII blanks. If the Problem Code is not equal to 6, the Conficting SHO ID field will contain either ASCII blanks or the ID of the SHO for which the OPM-51 is being sent. This field should be ignored if Problem Code is not equal to 6.

9.3.4.2 Return Channel Time Delay, OPM - Class 52

When a SHO includes a request for return channel time delay data, this message shall be used to send the NCC that data. The return channel time delay data will be obtained at the start and stop of the return service, when equipment configuration changes, and at service reconfiguration. These data will be sent to the NCC after termination of the return service. The message structure is:

# of Bytes	Data Item
12	OPM Header
11	OPM Subheader
	Time delay at service start (LSB = 1 microsecond)
7	I Channel
7	Q Channel
7	Spare
	Time delay at service stop (LSB = 1 microsecond)
7	I Channel
7	Q Channel
7	Spare
	Interim Time Delays
2	Number of Time Delays to follow
9	Day, Hour, Minute, Second of Delay Time
	Time Delay (LSB = 1 microsecond)
7	I Channel
7	Q Channel
7	Spare
67+30n	Repeat last 30 bytes as required

9.3.4.3 Preventive Maintenance (PM) Request, OPM - Class 53

The STGT shall request preventive maintenance (PM) periods from the NCC one week in advance of the requested date by using a preventive maintenance request message. The format for this message is free-form text; the message structure is:

# of Bytes	Data Item
12	OPM Header
2	Number of 4800-bit data blocks
Variable	Data field for alphanumeric text. Unused characters shall be set to space. This data field length is limited to 560 bytes in the first 4800-bit data block and 574 bytes in each succeeding 4800-bit data block.

The character set for free-form text messages is provided in Section 13.

9.3.4.4 Special Request or Information, OPM - Class 54

This message shall be used to send free-form alphanumeric text from the STGT to the NCC. The message structure is:

# of Bytes	Data Item
12	OPM Header
2	Number of 4800-bit data blocks
Variable	Data field for alphanumeric text. Unused characters shall be set to space. This data field length is limited to 560 bytes in the first 4800-bit data block and 574 bytes in each succeeding 4800-bit data block.

The character set for free-form text messages is provided in Section 13.

9.3.4.5 Service Terminated, OPM - Class 57

This message is sent from the STGT to the NCC to notify the NCC of the termination of a service. The message structure is:

# of Bytes	Data Item
12	OPM Header
11	OPM Subheader
1	Termination Reason: 0 = Normal completion of service 1 = Termination requested by OPM
1	Service Support Type: 0 = Forward 1 = Return 2 = Tracking 3 = Forward End-to-End Test 4 = Return End-to-End Test
7	Message ID of OPM or SHO which requested termination (set to blank if termination reason = 0)
	Termination Time
2	Year
3	Day
2	Hour
2	Minute
2	Second
43	

9.3.4.6 TDRS Maneuver Request, OPM - Class 59

When the STGT desires to perform a TDRS maneuver which might have an impact on providing service, approval must be requested from the NCC. The structure for this OPM message is:

# of Bytes	Data Item
12	OPM Header
1	TDRS ID A = TDRS 1300 B = TDRS 1301 C = TDRS 1302 D = TDRS 1303 E = TDRS 1304 F = TDRS 1305 G = TDRS 1306 H = TDRS 1307 I = TDRS 1308 J = TDRS 1309
1	Type of Maneuver: 0 = E/W Stationkeeping 1 = N/S Stationkeeping 2 = Satellite Repositioning
	Start -
2	Year
3	Day
2	Hour
2	Minute
2	Second
	Stop -
2	Year
3	Day
2	Hour

# of Bytes	Data Item
2	Minute
2	Second
Variable	Narrative field for comments (This alpha-numeric text field is limited to 538 bytes.)

9.3.4.7 Acknowledgment of Message Received, OPM - Class 60

In the event that there is no other pending message to be sent, this message shall be sent to acknowledge receipt of a message. This message structure consists of only the OPM header, since the "Acknowledgment" subfield in the data subfield provides the ID of the message satisfactorily received.

# of Bytes	Data Item
12	OPM Header

9.3.4.8 Spacecraft State Vector Rejection, OPM - Class 61

Upon receipt of a state vector, STGT performs checks. If any of these checks should result in the detection of an unusable state vector, this rejection OPM will be sent to the NCC. The message structure is:

# of Bytes	Data Item
12	OPM Header
4	User ID, Support Identification Code (SIC)
2	User ID, Vehicle Identification Code (VIC)
7	OPM ID (ID of the OPM - Class 10 or 15) of the rejected state vector message
	Epoch Time of the Rejected State Vector:
3	Day
2	Hour
2	Minute
5	Second (LSD = 1 millisecond)

# of Bytes	Data Item
1	Problem Code: 0 = Checksum Error 1 = Maneuver Vector out of sequence 2 = User state vector epoch time check failed 3 = Syntax error 4 = Maximum number of vectors for a single User exceeded 5 = Maximum number of vectors for STGT exceeded 6 = Vector Magnitude < 6356 kilometers 7 = No Type 2 or 8 8 = Invalid Earth Station Vector Type 9 = Spare

9.3.4.9 OPM Status, OPM - Class 62

OPM's received from the NCC will be checked for validity. If any of these validity checks should result in the detection of an erroneous OPM, an OPM status message will be sent to the NCC with a Problem Code from the list below.

For certain OPM classes, an acceptance message with the Problem Code set to zero will be sent, acknowledging receipt of an OPM without detected errors. These OPM classes are:

2	Reacquisition*
3	Reconfiguration*
4	Forward Link Sweep*
6	Forward Link EIRP Reconfiguration
7	Expanded User Frequency Uncertainty*
11	Doppler Compensation Inhibit*
12	Cancel SHO

The message structure is:

# of Bytes	Data Item
12	OPM Header
7	OPM ID of bad OPM message
2	OPM class code of bad message

* OPM-62 will be transmitted to the NCC upon completion of these actions at the STGT.

# of Bytes	Data Item
2	Problem Code: 0 = No problem 1 = Syntax error 2 = Specified SHO ID not found 3 = Specified service not found 4 = Specified service is not active or is undergoing change because of a preceding OPM, an equipment outage or a loss of lock 5 = Parameter out of range 6 = Incoming Queues Full 7 = User spacecraft not recognized 8 = OPM not applicable to the service designated 9 = Incomplete or ambiguous parameter designation 10 = Spare 11 = Equipment Conflict 12 = Required corresponding forward service is not in operation 13 = Connectivity table error (no TDRS/ground antenna match)
23	

9.3.4.10 Acquisition Failure Notification, OPM - Class 63

When an attempt to provide a return service requested in a SHO does not occur due to an inability to acquire or reacquire the user spacecraft, an acquisition failure notification OPM will be sent to the NCC. The affected SHO and service is identified in this message. The OPM header and subheader fully define this message:

# of Bytes	Data Item
12	OPM Header
11	OPM Subheader
23	

9.3.4.11 Real-Time Mode, OPM - Class 64

STGT shall use this OPM to notify the NCC when a user enters and exits the Real-Time Mode. This OPM shall also be used to inform the NCC that a Real-Time maneuver sequence was interrupted and STGT generated a type 2 or 8 vector.

# of Bytes	Data Item
12	OPM Header
11	OPM Subheader
1	1 = Real-Time Mode (enter) 2 = Normal Mode (exit) 3 = Real-Time Sequence interrupted
24	

9.3.4.12 Delta-T Adjustment Rejection, OPM - Class 65

This message shall be used by STGT to advise the NCC that a requested Delta-T adjustment has not been implemented. The structure of this message is:

# of Bytes	Data Item
12	OPM Header
4	User ID, Support Identification Code (SIC)
2	User ID, Vehicle Identification Code (VIC)
7	OPM ID (ID of the rejected Delta-T adjustment, OPM-Class 18)
1	Problem Code: 1 = Spare 2 = Delta-T adjustment greater than the maximum (11 hours 59 minutes 59 seconds) allowed 3 = Syntax Error
26	

9.3.4.13 Time Transfer, OPM - Class 66

This message shall be used to provide time transfer data to the NCC. This message shall be transmitted to the NCC within 1 minute of termination of service for which time transfer was requested in the SHO. Multiple blocks may be required.

# of Bytes	Data Item
12	OPM Header
11	OPM Subheader
4	Forward PN time delay (Binary, LSB = 10 nanoseconds)
4	Return PN time delay (Binary, LSB = 10 nanoseconds)
1	Number of Time Transfer Samples (Binary, 20 - 255)
5	NASA PB-1 Time Sample (Binary)
1	Receiver PN Lock 0 = No Lock 1 = Lock
3	Forward Delta Time (Binary, LSB = 200 nanoseconds)
3	Return Delta Time (Binary, LSB = 200 nanoseconds)
32 + 12n	Repeat last 12 bytes for each measurement

9.3.4.14 Stationkeeping/Momentum Dump Data, OPM - Class 67

The format and transmission requirements of this section are applicable to TDRS F1-F7 only. TDRS H, I, J requirements for OPM-Class 67 are TBS.

This message shall be manually generated and sent at least one hour prior to the first thruster action for stationkeeping maneuvers or at least 30 minutes prior to the first thruster action for momentum dump maneuvers. This message shall start in Byte 23 of the 4800 bit block. Bytes 19 through 22 shall contain zeros. This message shall be sent only to the LI on the LI TDM lines.

# of Bytes	Data Item
2	Message Type 03
	Message Date/Time:
2	Year
3	Day
2	Hour
2	Minute

# of Bytes	Data Item
1	Message Source 0 = STGT 1 = WSGTU
2	Message Class 67
4	TDRS SIC (1300-1399)
1	Activity 0 = Stationkeeping 1 = Momentum Dump
	Planned Start Time
3	Day
2	Hour
2	Minute
2	Second
	Planned Stop Time
3	Day
2	Hour
2	Minute
2	Second

Stationkeeping Information (Zeros if momentum dump)

# of Bytes	Data Item		
	Predicted Thruster Configuration		
4	1)	ID #1	(+/-,A-Z,0-9,A-Z)
4	2)	ID #2	(+/-,A-Z,0-9,A-Z)
4	3)	Spare	(Zeros)
4	4)	Spare	(Zeros)
	Predicted Delta Velocity (ft./sec.)		
8	1)	Body R	(+/-00.0000 to +/-99.9999)
8	2)	Body I	(+/-00.0000 to +/-99.9999)
8	3)	Body C	(+/-00.0000 to +/-99.9999)

Momentum Dump Information (Zeros if stationkeeping)

1	Dump Type 0 = roll/yaw 1 = pitch

# of Bytes	Data Item
	Predicted Thruster Configuration
4	1) ID #1 (+/-,A-Z,0-9,A-Z)
4	2) ID #2 (+/-,A-Z,0-9,A-Z)
4	3) Spare (Zeros)
4	4) Spare (Zeros)
	Predicted Pulse
2	Count (00-99)
	Predicted Start Momentum (Newtons/sec^2)
5	1) Hx ($\pm$0.00 to $\pm$1.00)
5	2) Hy ($\pm$0.00 to $\pm$1.00)
5	3) Hz ($\pm$0.00 to $\pm$1.00)
	Predicted Stop Momentum (Newtons/sec^2)
5	1) Hx ($\pm$0.00 to $\pm$1.00)
5	2) Hy ($\pm$0.00 to $\pm$1.00)
5	3) Hz ($\pm$0.00 to $\pm$1.00)
	Predicted Momentum Wheel
7	1) Delta RPM Sum ($\pm$000.00 to $\pm$999.00)
7	2) Delta RPM Difference ($\pm$000.00 to $\pm$999.00)
140	

9.4 Message Subfield for SLR's (Service Level Status Report)

The STGT service level status information shall be sent from the STGT to the NCC in the form of service level status report (SLR's) as changes in equipment status occur or as requested verbally by the NCC.

9.4.1 SLR Header

The SLR provides the service availability of the STGT to the NCC for user service scheduling. SLR's shall be sent to the NCC (1) upon verbal request from the NCC, (2) upon change in any reported parameter within 15 minutes of the change.

The structure of an SLR header is:

(Byte #s)	(# of Bytes)	Data Item
23-24	2	Message type 1 = Tracking Data 2 = SHO - Routine 3 = OPM => 4 = SLR 5 = SA/SMAR Operations Data 6 = MA/SMAF Operations Data 7 = End-to-End Test Operations Data 8 = SHO - Periodic
25-31	7	SLR ID - A seven-digit number. SLR's shall be sequentially numbered in the order sent.*
32	1	SLR Type 0 = Report caused by change in equipment status 1 = Report by the NCC Verbal request
		Date/Time of SLR:
33-34	2	Year
35-37	3	Day
38-39	2	Hour
40-41	2	Minute
42-43	2	Second
	21	

* SLR's which are sent for an equipment status change shall be numbered from 1 to 4,999,999 to 1. SLR's which are sent in response to a NCC request shall be numbered from 5,000,000 to 9,999,999 to 5,000,000.

9.4.1.1 SLR

The SLR Message shall use the following format:

(Byte #s)	(# of Bytes)	Data Item		
		SGLT 1 Service Chains		
44-45	2	SSA1F	N,C/0,1,2	2 = P&R
46-47	2	SSA1R	N,C/0,1,2	1 = P only
48-49	2	KSA1F/KaSA1F	N,C/0,1,2	0 = Unavailable
50-51	2	KSA1R/KaSA1R	N,C/0,1,2	N = No Change
52-53	2	Spare		C = Change
54-55	2	Spare		
56-67	2/service	(Repeat for SA2)	N,C/0,1,2	
68-69	2	MAF/SMAF	N,C/0,1,2	
70-72	3	MAR/SMAR	N,C/00-05	Number of MA/SMA return services available.
73-74	2	End-to-End Test	N,C/0,1	End-To-End Test is for all services except Ka. 1 = Available
		Computer Subsystems		
75-76	2	TT&C	N,C/0,1,2	USS1, USS2 or
77-78	2	USS1	N,C/0,1,2	MA=0 implies
79-80	2	USS2	N,C/0,1,2	no services
81-82	2	MA/SMA	N,C/0,1,2	available for
83-84	2	EXEC	N,C/0,1,2	SSA1/KSA1/KaSA1,
85-86	2	LAN(CDCN)	N,C/0,1	SSA2/KSA2/KaSA2 or MA/SMA. TT&C, Executive (EXEC) or LAN = 0 implies no services available for this SGLT.

SLR (Cont.)

(Byte #s)	(# of Bytes)	Data Item		
		SGLT 1 Service Chains		
		TT&C Chains		
87-88	2	Command (CMD)	N,C/0,1,2	
89-90	2	Telemetry (TLM)	N,C/0,1,2	
91-92	2	Range	N,C/0,1,2	
		SGLT 2 Service Chains		
93-141		(Repeat of 49 bytes of SGLT 1)		
		SGLT 3 Service Chains		
142-190		(Repeat of 49 bytes of SGLT 1)		
		STGT Antennas		
191-192	2	North	N,C/0,1	1 = Available
193-194	2	Central	N,C/0,1	0 = Unavailable
195-196	2	South	N,C/0,1	North, Central and
197-198	2	End-to-End 1	N,C/0,1	South refer to
199-200	2	End-to-End 2	N,C/0,1	K-Band availability
201-202	2	End-to-End 3	N,C/0,1	only.
		DIS and CTFS		
203-206	4	Multiplexer (MUX) (P)	N,C/000-075	000-0XX = number
207-210	4	MUX (R)	N,C/000-075	available
211-214	4	GSFC DEMUX (P)	N,C/000-030	
215-218	4	GSFC DEMUX (R)	N,C/000-030	
219-222	4	JSC DEMUX (P)	N,C/000-030	
223-226	4	JSC DEMUX (R)	N,C/000-030	
227-228	2	HDR MUX	N,C/0,1,2	
229-230	2	HDR DEMUX	N,C/0,1,2	
231-232	2	X MUX (Cross Strap Mux)	N,C/0,1,2	
233-235	3	LOR DEMUX	N,C/00-10	
236-237	2	A/B Switch (GSFC)	N,C/0,1	
238-239	2	A/B Switch (JSC)	N,C/0,1	
240-241	2	HDRR/P ($\leq$ 150 Mbps)	N,C/n	n = number available

SLR (Cont.)

(Byte #s)	(# of Bytes)	Data Item		
		DIS and CTFS (Cont.)		
242-243	2	SUE	N,C/0,1,2	
244-245	2	SRDP	N,C/0,1,2	
246-247	2	ADPE	N,C/0,1,2	
248-249	2	LAN Backbone	N,C/0,1	
250-251	2	LRBS	N,C/0,1	
252-253	2	HRBS	N,C/0,1	
254-255	2	CTFS	N,C/0,1	
256-257	2	Secure/GSFC	N,C/0,1,2	
258-259	2	Secure/Other GT	N,C/0,1,2	
		TDRS		
260-261	2	Spacecraft/ Available	A-J/A,S	A = All Serv. unavailable
262-263	2	SSA1F/R	0,1/0,1	S = Specified Serv.
264-265	2	KSA1F/R, KaSA1F/R	0,1/0,1	1 = Available
266-267	2	SSA2F/R	0,1/0,1	0 = Unavailable
268-269	2	KSA2F/R, KaSA2F/R	0,1/0,1	A-J = TDRS ID
270-271	2	MA/SMA F/R	0,1/0,1	
272-319		(Repeat 12 bytes for 4 more spacecraft)		ASCII spaces indicate N/A
		Affected SHO I.D.		
320-321	2	Number of SHO's affected (n)		When a SHO is no longer affected, it will be deleted from the list.
322-328	7	SHO I.D.1	xxxxxxx	
. .	. .	. .	. .	
322-328+7(n-1)	7	SHO I.D.n	yyyyyyy	

SLR (Cont.)

(Byte #s)	(# of Bytes)	Data Item	
		ETRO	
322-332+7n	11	ETRO/Byte 1	N,C/d,d,d,h,h,m,m/xxx
.	.	.	.
.	.	.	.
322-332+7n+11(m-1)	11	ETRO/Byte m	N,C/d,d,d,h,h,m,m/yyy

Notes:

(1) Affected SHO's are those which were in the STGT integrated schedule but can no longer be supported because of an equipment failure. Only those SHO's whose earliest start time is earlier than the ETRO are affected SHO's. Receipt of new SHO's which are affected will also generate SLR's.

(2) Estimated Time of Return to Operation (ETRO)/Byte is the estimated time of day to restore to operation the service or equipment whose first byte number is specified. If both P&R are unavailable, ETRO is the time to restore one (1) service or equipment. ETRO's will be listed in order of ascending byte numbers.

(3) P = Prime R = Redundant

(4) The SLR sent upon request from the NCC shall be the last previously sent SLR.

(5) Secure/GSFC and other GT include MUX/DEMUX, BED and Security Equipment.

(6) DIS ADPE, BACKBONE Local Area Network (LAN), Secure/GSFC or Common Time and Frequency System (CTFS) unavailable implies no NCC schedulable services from STGT.

(7) Low Rate Black Switch (LRBS) unavailable implies no data via the MDM.

(8) High Rate Black Switch (HRBS) unavailable implies no LI data >10 Mbps and no non LI data >7 Mbps.

(9) ETRO's will be updated (new SLR) 10 minutes prior totheir expiration.

(10) When redundant ADPE are in the Maintenance and Software Delivery Mode (MSM), they are considered to be available for user service.

(11) Affected SHO's will be deleted from the SLR's (new SLR sent) at the SHO stop time.

(12) All parameters are reported in each SLR.

(13) A/B Switch (GSFC) = 0 implies no output from X MUXs and no input from GSFC DEMUXs.

9.5 Message Subfield for ODM's

The message subfield of the 4800-bit data block (bytes 23 through 596) shall be used to send operation data messages (ODM's). These messages shall be sent from STGT to the NCC once every five seconds. The staleness of the data provided at the DIS interface shall not exceed five seconds relative to the time that the data were acquired. The time tag in the ODM's shall be the time at which the data in the ODM were acquired. ODM's shall be sent from STGT to the NCC only for ongoing services.

An ODM consists of a header followed by a combination of subheaders and structured data items, to indicate each specific service and provide the related data.

For TDRS H, I, and J S-Band MA return service (SMAR) ODM's shall be provided within SA ODM formats while S-Band MA forward service (SMAF) ODMs shall be provided within MA ODM formats.

Separate SA/SMAR, MA/SMAF, and End-to-End Test ODM's are used to report on the active services for each TDRS. Therefore, if three TDRS's are providing both SA/SMAR and MA/SMAF services, six ODM's are required to report these operations data.

Angles 1, 2, and 3 in the following ODM headers provide the orientation of the corrected local TDRS coordinate system relative to the NASA-defined coordinate system. The corrected local TDRS coordinate system is the spacecraft body coordinate system with the origin at the spacecraft center-of-mass, the Z-axis along the spacecraft longitudinal centerline, the Y-axis parallel to the solar array rotational axis and pointed toward the SGL antenna side of the spacecraft, and the X-axis completing the right-handed set. The NASA-defined coordinate system is the spacecraft attitude reference coordinate system with the origin at the spacecraft center of mass, the Z-axis in the orbit plane pointed toward nadir, the X-axis in the orbit plane pointed in the direction of spacecraft orbital motion, and the Y-axis completing the right-handed set. These angles transform the attitude reference coordinates to body coordinates, given by the following order of rotations: Angle 1 (yaw), a rotation about the Z-reference-axis; angle 2 (roll), a rotation about the resultant X-axis; and angle 3 (pitch), a rotation about the resultant Y-axis. The orientation of the corrected local TDRS coordinate system (body coordinates) relative to the NASA-defined coordinate system (attitude reference coordinates) will be provided to an accuracy of 0.1° in pitch and roll and 0.25° in Yaw.

RF beam pointing data in the ODM's provide the orientation of the RF beam relative to the TDRS orientation. The angles to be reported shall be derived from the TDRS to user vector from which MA beamforming data was derived. The RF beam pointing parameters will be given as rotation angles from the spacecraft body coordinate system in the following order: Azimuth, a rotation about the Y-body-axis; and Elevation, a rotation about the resultant X-axis. The RF beam pointing shall be provided to an accuracy of 0.5° for SA and 2.0° for MA.

9.5.1 SA/SMAR ODM Header

An SA/SMAR ODM header is structured as follows:

Byte #'s	# of Bytes	Data Item
23-24	2	Message Type 1 = Tracking Data 2 = SHO - Routine 3 = OPM (Operations) 4 = SLR (TDRSS Service Level Status) => 5 = SA/SMAR Operations Data 6 = MA/SMAF Operations Data 7 = End-to-End Test Operations Data 8 = SHO - Periodic
25-31	7	ODM ID The ID is a seven digit number. ODM's shall be sequentially numbered in the order sent, 1 to 9,999,999 to 1.
32	1	Spare
33	1	TDRS ID A = TDRS 1300 B = TDRS 1301 C = TDRS 1302 D = TDRS 1303 E = TDRS 1304 F = TDRS 1305 G = TDRS 1306 H = TDRS 1307 I = TDRS 1308 J = TDRS 1309
		TDRS Orientation (Defined in Section 9.5)
34-37	4	Angle 1-Yaw (0-360°, to accuracy of 0.25°) } LSD = 0.1
38-41	4	Angle 2-Roll (0-360°, to accuracy of 0.1°) } LSD = 0.1
42-45	4	Angle 3-Pitch (0-360°, to accuracy of 0.1°) } LSD = 0.1
		Time Tag:
46-47	2	Year
48-50	3	Day

Byte #'s	# of Bytes	Data Item
51-52	2	Hour
53-54	2	Minute
55-56	2	Second
57-58	2	Number of SA/SMAR Services Reported in this ODM*
	36	

* For TDRS A-G a maximum of 8 SA services (KSA2F, KSA2R, KSA1F, KSA1R, SSA2F, SSA2R, SSA1F, and SSA1R) may be reported. For TDRS H, I, and J a maximum of 13 (8 plus an additional 1-5 SMA services) may be reported.

9.5.2 SA/SMAR ODM Subheaders No. 1 thru 9

A selection of SA/SMAR ODM subheaders are used in an ODM, depending upon the type of SA/SMAR services for which the operations data is being reported. This causes variable positions for these and succeeding data within the message field.

9.5.2.1 SA/SMAR ODM Subheader No. 1

The structure of this subheader is:

# of Bytes	Data Item
1	Service Support Type 0 = Forward 1 = Return
7	Support Identifier Code (SUPIDEN)
2	Vehicle Identification Code (VIC)
1	Service Support Subtype 1 = SSA1 (Antenna 1) 2 = SSA2 (Antenna 2) 3 = KSA1 (Antenna 1) 4 = KSA2 (Antenna 2) 5 = SMA 6 = KaSA1 (Antenna 1) 7 = KaSA2 (Antenna 2)
1	Support Function Subgroup 0 = Not Applicable* 1 = DG1 2 = DG2 3 = Shuttle

* Field will be 0 = NA for Forward Service to normal user.
  Field will be 3 = Shuttle for Forward and Return Services to Shuttle.

# of Bytes	Data Item
3	Spare
	RF Beam Pointing - Defined in Section 9.5
4	Azimuth $\pm 90^\circ$ Sign, 3 Digits (LSD = 0.1°)
4	Elevation $\pm 90^\circ$ Sign, 3 Digits (LSD = 0.1°)
1	Service Configuration 0 = Not Used 1 = SSA 2 = KSA 3 = Shuttle 4 = SMA 5 = KaSA
1	Polarization 0 = LCP 1 = RCP
1	Link Status 0 = Active Status will be active during the following conditions: a. Forward service is set-up and running b. Return service has achieved link lock 1 = Pending (equipment unavailable for service) Status will be pending during the following conditions: a. Both prime and redundant equipment required for this support are FAILED b. No TTC look angles available for antenna service c. No USS doppler correction d. Equipment not configured/reconfigured (event processing error) 2 = Acq/reacq (service is being initiated/ reinitiated/reconfigured) Status will be acq/reacq during the following conditions: a. Link lock has not been achieved for initiation of a return service b. Link lock is not achieved for a return service recovering from a PENDING state c. Link lock is not achieved for a return service undergoing reconfiguration/reacquisition

# of Bytes	Data Item
2	Spare
28	

9.5.2.2 SA ODM Subheader No. 2

The structure of this subheader is:

# of Bytes	Data Item
1	Command Channel PN Modulation 0 = No 1 = Yes
1	Doppler Compensation 0 = Off 1 = On
4	Signal EIRP Sign, 3 Digits (LSD = 0.1 dBw)*
10	Radiated Carrier Frequency (LSD = 10 Hz)**
1	Power Mode 0 = Normal 1 = High
1	Clock Presence (for all 5 seconds of the reporting interval) 0 = No 1 = Yes
2	Data Transition Density Percent Transitions (average of 5 one-second readings) 2 Digits (00-99)
20	

* Signal EIRP shall be obtained from a table look-up, based on forward power mode, i.e., Normal or High/Acquisition. The tables shall be periodically updated, whenever the analogous tables for Pin Diode Attenuator (PDA) settings for the forward power modes are updated.

** Radiated Carrier Frequency shall be set to the carrier frequency calculated for Doppler compensation and inhibit.

9.5.2.3 SA/SMAR ODM Subheader No. 3

The structure of this subheader is:

# of Bytes	Data Item
1	Receiver Configuration 0 = Normal 1 = Cross-support
1	Doppler Tracking Status 0 = Inactive 1 = One-Way 2 = Two-Way 3 = Cross-support
	First Demodulator: (I Channel)*
1	Type 1 = Integrated Receiver (IR) 2 = High Data Rate Receiver (HDRR)
1	Lock Indicator 0 = No Lock 1 = Lock
5	Signal Strength C/N_o (LSB = 0.1 dB-Hz)*
	Second Demodulator: (Q Channel)*
1	Type 1 = IR 2 = HDRR
1	Lock Indicator 0 = No Lock 1 = Lock
5	Signal Strength C/N_o (LSB = 0.1 dB-Hz)*
16	

* When Demodulator Type is HDRR, Signal Strength C/N_o will be set invalid (ASCII Space). When the Demodulator Type is IR and the I or Q Channel BER Status equals 7 or 8, the reported C/N_o will be a minimum. If the demodulator is not used, both Type and Signal Strength C/N_o will be ASCII Space.

9.5.2.4 SA/SMAR ODM Subheader No. 4

The structure of this subheader is:

# of Bytes	Data Item
1	Symbol Synchronizer Lock Indication - I Channel 0 = No Lock 1 = Lock
1	Symbol Synchronizer Lock Indicator - Q Channel 0 = No Lock 1 = Lock
1	BER Status - I Channel 0 = Status not valid* 1 = BER $\geq 10^{-3}$ 2 = 10^{-3} > BER $\geq 10^{-4}$ 3 = 10^{-4} > BER $\geq 10^{-5}$ 4 = 10^{-5} > BER $\geq 10^{-6}$ 5 = 10^{-6} > BER $\geq 10^{-7}$ 6 = 10^{-7} > BER $\geq 10^{-8}$ 7 = 10^{-8} > BER $\geq 10^{-9}$ 8 = BER < 10^{-9}
1	BER Status - Q Channel 0 = Status not valid* 1 = BER $\geq 10^{-3}$ 2 = 10^{-3} > BER $\geq 10^{-4}$ 3 = 10^{-4} > BER $\geq 10^{-5}$ 4 = 10^{-5} > BER $\geq 10^{-6}$ 5 = 10^{-6} > BER $\geq 10^{-7}$ 6 = 10^{-7} > BER $\geq 10^{-8}$ 7 = 10^{-8} > BER $\geq 10^{-9}$ 8 = BER < 10^{-9}
4	

* BER Status not valid indicates no BIT SYNC Lock for uncoded service and no decoder lock for coded service. When Demodulator Type is HDRR (Subheader 3) and channel is configured for uncoded data, BER status will be set to not valid.

9.5.2.5 SA/SMAR ODM Subheader No. 5

The structure of this subheader is:

# of Bytes	Data Item
1	Data Format Conversion Configuration -I Channel 0 = No 1 = Yes
1	Data Format Conversion Configuration - Q Channel 0 = No 1 = Yes
3	I/Q Channel Power Ratio* Sign, 2 Digits (LSD = 0.1 dB)
1	Symbol Format Conversion from BIφ to NRZ - I Channel 0 = No 1 = Yes
1	Symbol Format Conversion from BIφ to NRZ - Q Channel 0 = No 1 = Yes
1	Data Channel Configuration SSAR/SMAR 0 = Single Data Source Identical coded data on I and Q Channels (DG1) G1 on I Channel, G2 on Q Channel (DG2) 1 = Dual Data Source 2 = Single Data Source G1 G2 (G3) of Alternate Data Bits on I Channel G1 G2 (G3) of Alternate Data Bits on Q Channel KSAR/KaSAR 0 = Single Data Source 1 = Dual Data Source
8	

* This is the value for which the equipment is configured, i.e., from the SHO or OPM-03. The I/Q Channel Power Ratio will be ASCII space when BPSK is used.

9.5.2.6 SA/SMAR ODM Subheader No. 6

The structure of this subheader is:

# of Bytes	Data Item
1	Data Coding, I Channel 0 = Uncoded 1 = Code 1 (Rate 1/2) 2 = Code 2 (Rate 1/2) 3 = Code 3 (Rate 1/3)
1	Data Coding, Q Channel 0 = Uncoded 1 = Code 1 (Rate 1/2) 2 = Code 2 (Rate 1/2) 3 = Code 3 (Rate 1/3)
1	G2 Inversion, I Channel 0 = Not inverted 1 = Inverted (ASCII space when Code 2 or 3 selected)
1	G2 Inversion, Q Channel 0 = Not inverted 1 = Inverted (ASCII space when Code 2 or 3 selected)
4	

9.5.2.7 SA/SMAR ODM Subheader No. 7

The structure of this subheader is:

# of Bytes	Data Item
1	DG1 Configuration 0 = I Channel Only 1 = Q Channel Only 2 = I and Q Channel
1	Range Tracking Status 0 = Inactive 1 = Normal 2 = Cross-support
1	Mode 1 = Mode 1 2 = Mode 2 3 = Mode 3

# of Bytes	Data Item
1	Receiver Coherency Indicator* 0 = Noncoherent 1 = Coherent
4	

9.5.2.8 SA/MA/SMA ODM Subheader No.8

The structure of this subheader is as follows. The 19 bytes shown will be repeated once (total of 38 bytes) for all ODMs except KSA Shuttle Return which will contain 2 repeats (total of 57 bytes) and SSA Shuttle which contains 19 bytes total. For Single Data Source only the first 19 bytes will be applicable. For Dual Data Source the first 19 byte field is for the I Channel and the second 19 byte field is for the Q Channel. For K-Shuttle the three 19 byte fields are for channels 1, 2, and 3. For K-Shuttle Mode 2, Channel 3 Subheader No. 8 is not applicable (i.e., ASCII Spaces). If DQM is not required for a channel, the 19 bytes will be ASCII Spaces.

# of Bytes	Data Item
1	Frame Synch Mode (at end of reporting period) 0 = Search 1 = Check 2 = Lock 3 = Flywheel
1	Clock Presence (for all 5 seconds of the reporting interval) 0 = No 1 = Yes
2	Data Transition Density Percent Transitions (average of 5 one-second readings) 2 Digits (00-99)
3	Percent Frames in Lock (Defined as the number of frames in lock divided by the expected number of frames during the 5 second reporting period)

$$\%\text{Frames in Lock} = \frac{\text{Frame Lock Count}}{\text{Expected Frames}} \times 100$$

$$\%\text{Frames in Lock} = \frac{\text{Frame Lock Count}}{5 \times \left(\dfrac{\text{Data Rate}}{\text{Frame Length}}\right)} \times 100$$

000 - 100

* This is an indicator of the user's carrier mode, i.e., coherent or non-coherent, as specified in the SHO or OPM-03.

# of Bytes	Data Item
8	Sync Lock Dropout Count (for 5 second reporting interval) 00000000 - 99999999
4	Frame Sync Word BER (at ODM time tag) XEYY (exponent is assumed negative)
19	

9.5.2.9 SA/SMAR ODM Subheader No. 9

The structure of this subheader is:

# of Bytes	Data Item
1	Receiver Configuration 0 = Normal 1 = Cross-support
1	Doppler Tracking Status 0 = Inactive 1 = One-way 2 = Two-way 3 = Cross-support
	Data for SSA1/SMAR (1-5):*
1	IR Lock Indicator 0 = No Lock 1 = Lock
5	IR Signal Strength C/N_o (LSB = 0.1 dB-Hz)**
1	SMA Return Link ID (1-5) (obtained from SHO)
1	SMA Return Link ID (1-5) (ID of SMAR equipment string including receiver)

* Data for SSA1 and SMAR service will appear under SSA1. Data for SSA2 service will appear under SSA2, except for "deinterleaving selection," which is common to both SSA1, SSA2 and SMAR. For SSA1/SMAR services the first 18 bytes and the Deinterleaving selection byte of SA/SMAR ODM Subheader No. 9 are applicable. For SSA2 services the first 2 bytes, and bytes 19 through 35 of SA/SMAR ODM Subheader No. 9 are applicable. All non-applicable bytes are set to ASCII space (Ground Rule 9 in Section 2.2.5). For SSA combining all bytes of SA/SMAR ODM Subheader No. 9 are applicable. It is understood that, depending on the SSA combining approach, some parameters in the SSA1/SMAR and SSA2 fields will be identical, i.e., from the same indicators. Data for SSA combining service will appear under both SSA1/SMAR and SSA2.

** When the I or Q Channel BER Status equals 7 or 8, the reported C/N_o will be a minimum.

# of Bytes	Data Item
4	Spare
1	Symbol Synchronizer Lock Indicator - I Channel 0 = No Lock 1 = No Lock
1	Symbol Synchronizer Lock Indicator - Q Channel 0 = No Lock 1 = No Lock
1	BER Status - I Channel 0 = Status not valid* 1 = BER $\geq 10^{-3}$ 2 = 10^{-3} > BER $\geq 10^{-4}$ 3 = 10^{-4} > BER $\geq 10^{-5}$ 4 = 10^{-5} > BER $\geq 10^{-6}$ 5 = 10^{-6} > BER $\geq 10^{-7}$ 6 = 10^{-7} > BER $\geq 10^{-8}$ 7 = 10^{-8} > BER $\geq 10^{-9}$ 8 = BER < 10^{-9}
1	BER Status - Q Channel 0 = Status not valid* 1 = BER $\geq 10^{-3}$ 2 = 10^{-3} > BER $\geq 10^{-4}$ 3 = 10^{-4} > BER $\geq 10^{-5}$ 4 = 10^{-5} > BER $\geq 10^{-6}$ 5 = 10^{-6} > BER $\geq 10^{-7}$ 6 = 10^{-7} > BER $\geq 10^{-8}$ 7 = 10^{-8} > BER $\geq 10^{-9}$ 8 = BER < 10^{-9}
	Data for SSA2:**

* BER Status not valid indicates no BIT SYNC Lock for uncoded service, and no decoder lock for coded service.

** Data for SSA1 and SMAR service will appear under SSA1. Data for SSA2 service will appear under SSA2, except for "deinterleaving selection," which is common to both SSA1, SSA2 and SMAR. For SSA1/SMAR services the first 18 bytes and the Deinterleaving selection byte of SA/SMAR ODM Subheader No. 9 are applicable. For SSA2 services the first 2 bytes, and bytes 19 through 35 of SA/SMAR ODM Subheader No. 9 are applicable. All non-applicable bytes are set to ASCII space (Ground Rule 9 in Section 2.2.5). For SSA combining all bytes of SA/SMAR ODM Subheader No. 9 are applicable. It is understood that, depending on the SSA combining approach, some parameters in the SSA1/SMAR and SSA2 fields will be identical, i.e., from the same indicators. Data for SSA combining service will appear under both SSA1/SMAR and SSA2.

# of Bytes	Data Item
1	IR Lock Indicator 0 = No Lock 1 = Lock
5	IR Signal Strength C/N_o (LSB = 0.1 dB-Hz)**
1	Spare
5	Spare
1	Symbol Synchronizer Lock Indicator - I Channel 0 = No Lock 1 = Lock
1	Symbol Synchronizer Lock Indicator - Q Channel 0 = No Lock 1 = Lock
1	BER Status - I Channel 0 = Status not valid* 1 = BER $\geq 10^{-3}$ 2 = 10^{-3} > BER $\geq 10^{-4}$ 3 = 10^{-4} > BER $\geq 10^{-5}$ 4 = 10^{-5} > BER $\geq 10^{-6}$ 5 = 10^{-6} > BER $\geq 10^{-7}$ 6 = 10^{-7} > BER $\geq 10^{-8}$ 7 = 10^{-8} > BER $\geq 10^{-9}$ 8 = BER < 10^{-9}
1	BER Status - Q Channel 0 = Status not valid* 1 = BER $\geq 10^{-3}$ 2 = 10^{-3} > BER $\geq 10^{-4}$ 3 = 10^{-4} > BER $\geq 10^{-5}$ 4 = 10^{-5} > BER $\geq 10^{-6}$ 5 = 10^{-6} > BER $\geq 10^{-7}$ 6 = 10^{-7} > BER $\geq 10^{-8}$ 7 = 10^{-8} > BER $\geq 10^{-9}$ 8 = BER < 10^{-9}

* BER Status not valid indicates no BIT SYNC Lock for uncoded service, and no decoder lock for coded service.

** When I or Q Channel BER Status equals 7 or 8, the reported C/N_o will be a minimum.

# of Bytes	Data Item
1	Deinterleaving Selection* 0 = No deinterleaving 1 = I deinterleaved 2 = Q deinterleaved 3 = I & Q deinterleaved
1	Spare
36	

9.5.3 SA/SMAR ODM's

These messages are made up of an SA/SMAR ODM header and a selection of SA/SMAR ODM subheaders, followed by additional data items, the structures of which are provided in the following sections:

9.5.3.1 SSA1 Forward

# of Bytes	Data Item
28	SA/SMAR ODM Subheader No. 1
20	SA ODM Subheader No. 2
19	SA/MA/SMA ODM Subheader No.8 (Shuttle only- ASCII spaces when N/A)
1	Shuttle Carrier Doppler Compensation 0 = Off 1 = On
1	Shuttle PN Modulation 0 = Off 1 = On
1	Shuttle PN Rate Doppler Compensation 0 = Off 1 = On
1	Shuttle Data Configuration 1 = Mode 1 2 = Mode 2
71	

* If a channel is not used or if uncoded, this byte will be ASCII Space.

9.5.3.2 SSA2 Forward

This SA structure is the same as that for SSA1 Forward (9.5.3.1), except that the service support subtype in Subheader No. 1 equals 2.

9.5.3.3 KSA1/KaSA1 Forward

# of Bytes	Data Item
28	SA/SMAR ODM Subheader No. 1
20	SA ODM Subheader No. 2
19	SA/MA/SMA ODM Subheader No. 8 (Shuttle only - ASCII spaces when N/A)
67	

9.5.3.4 KSA2/KaSA2 Forward

This ODM structure is the same as that for KSA1 Forward (9.5.3.3), except that the service support subtype in Subheader No. 1 equals 4 or 7 as applicable.

9.5.3.5 SSA1/SMA DG1 Return*

# of Bytes	Data Item
28	SA/SMAR ODM Subheader No. 1
36	SA/SMAR ODM Subheader No. 9
8	SA/SMAR ODM Subheader No. 5
4	SA/SMAR ODM Subheader No. 6
4	SA/SMAR ODM Subheader No. 7
38	SA/MA/SMA ODM Subheader No. 8
1	SSA Combining (Note: ASCII Space for SMA service) 0 = No 1 = Yes
1	Spare
120	

* TDRS H, I, J SMA Return services will be provided within the SSA return format for up to five services and be provided using DG1 or DG2 formats as appropriate. Service support subtype will be 5 for these services.

9.5.3.6 SSA1/SMA DG2 Return*

# of Bytes	Data Item
28	SA/SMAR ODM Subheader No. 1
36	SA/SMAR ODM Subheader No. 9
8	SA/SMAR ODM Subheader No. 5
4	SA/SMAR ODM Subheader No. 6
38	SA/MA/SMA ODM Subheader No. 8
1	SSA Combining (Note: ASCII Space for SMA service) 0 = No 1 = Yes
1	DG2 Modulation 0 = QPSK 1 = BPSK
1	Receiver Coherency Indicator** 0 = Noncoherent 1 = Coherent
117	

9.5.3.7 SSA1 Shuttle Return

# of Bytes	Data Item
28	SA/SMAR ODM Subheader No. 1
19	SA/MA/SMA ODM Subheader No. 8
1	Receiver Configuration 0 = Normal 1 = Cross-support
1	Receiver Coherency Indicator** 0 = Noncoherent 1 = Coherent

* TDRS H, I, J SMA Return services will be provided within the SSA return format for up to five services and be provided using DG1 or DG2 formats as appropriate. Service support subtype will be 5 for these services.

** This is an indicator of the user's carrier mode, i.e., coherent or non-coherent, as specified in the SHO or OPM-03.

# of Bytes	Data Item
1	Doppler Tracking Status 0 = Inactive 1 = One-way 2 = Two-way 3 = Cross-support
1	SSA Combining 0 = No 1 = Yes
1	Mode 1 = Mode 1 2 = Mode 2 3 = Mode 3
3	Spare
	Data for SSA1*
1	IR Lock Indicator 0 = No Lock 1 = Lock
5	IR Signal Strength C/N_o (LSB = 0.1 dB-Hz)**
1	BER Status 0 = Status not valid 1 = BER $\geq 10^{-3}$ 2 = $10^{-3} >$ BER $\geq 10^{-4}$ 3 = $10^{-4} >$ BER $\geq 10^{-5}$ 4 = $10^{-5} >$ BER $\geq 10^{-6}$ 5 = $10^{-6} >$ BER $\geq 10^{-7}$ 6 = $10^{-7} >$ BER $\geq 10^{-8}$ 7 = $10^{-8} >$ BER $\geq 10^{-9}$ 8 = BER $< 10^{-9}$
1	Symbol Synchronizer Lock Indication 0 = No Lock 1 = Lock

* Data for SSA1 service will appear under SSA1. Data for SSA2 service will appear under SSA2. Data for SSA combining service will appear under both SSA1 and SSA2. For SSA combining, if data from either SSA1 or SSA2 is invalid, both SSA1 and SSA2 will be invalid.

** When the I and Q Channel BER Status equals 7 or 8, the reported C/N_o will be a minimum.

# of Bytes	Data Item
	Data for SSA2*
1	IR Lock Indicator 0 = No Lock 1 = Lock
5	IR Signal Strength C/N_o (LSB = 0.1 dB-Hz)**
1	BER Status 0 = Status not valid 1 = BER $\geq 10^{-3}$ 2 = 10^{-3} > BER $\geq 10^{-4}$ 3 = 10^{-4} > BER $\geq 10^{-5}$ 4 = 10^{-5} > BER $\geq 10^{-6}$ 5 = 10^{-6} > BER $\geq 10^{-7}$ 6 = 10^{-7} > BER $\geq 10^{-8}$ 7 = 10^{-8} > BER $\geq 10^{-9}$ 8 = BER < 10^{-9}
1	Symbol Synchronizer Lock Indication 0 = No Lock 1 = Lock
71	

9.5.3.8 Deleted

9.5.3.9 SSA2 DG1 Return

This ODM structure is the same as that for SSA1 DG1 return (9.5.3.5), except that the service support subtype in Subheader No. 1 equals 2.

9.5.3.10 SSA2 DG2 Return

This ODM structure is the same as that for SSA1 DG2 return (9.5.3.6), except that the service support subtype in Subheader No. 1 equals 2.

* Data for SSA1 service will appear under SSA1. Data for SSA2 service will appear under SSA2. Data for SSA combining service will appear under both SSA1 and SSA2.
For SSA combining, if data from either SSA1 or SSA2 is invalid, both SSA1 and SSA2 will be invalid.

** When the I and Q Channel BER Status equals 7 or 8, the reported C/N_o will be a minimum.

9.5.3.11 SSA2 Shuttle Return

This ODM structure is the same as that for SSA1 shuttle return (9.5.3.7), except that the service support subtype in Subheader No. 1 equals 2.

9.5.3.12 Deleted

9.5.3.13 KSA1/KaSA1 DG1 Return

# of Bytes	Data Item
28	SA/SMAR ODM Subheader No. 1
16	SA/SMAR ODM Subheader No. 3
4	SA/SMAR ODM Subheader No. 4
8	SA/SMAR ODM Subheader No. 5
4	SA/SMAR ODM Subheader No. 6
4	SA/SMAR ODM Subheader No. 7
38	SA/MA/SMA ODM Subheader No. 8
1	Autotrack Status 0 = Disabled 1 = No signal presence indication } Search Mode } Enabled 2 = Signal presence - no zero crossing } Search Mode } Enabled 3 = Zero crossing - both axes } Enabled 4 = Autotrack - fine pointing mode
6	Spare
109	

9.5.3.14 KSA1/KaSA1 DG2 Return

# of Bytes	Data Item
28	SA/SMAR ODM Subheader No. 1
16	SA/SMAR ODM Subheader No. 3
4	SA/SMAR ODM Subheader No. 4
8	SA/SMAR ODM Subheader No. 5
4	SA/SMAR ODM Subheader No. 6
38	SA/MA/SMA ODM Subheader No. 8
1	Autotrack Status 0 = Disabled 1 = No signal presence indication } Search Mode } Enabled 2 = Signal presence - no zero crossing } Search Mode } Enabled 3 = Zero crossing - both axes } Enabled 4 = Autotrack - fine pointing mode } Enabled
6	Spare
1	DG2 Modulation 0 = QPSK 1 = BPSK
1	Receiver Coherency Indicator* 0 = Noncoherent 1 = Coherent
1	Spare
108	

* This is an indicator of the user's carrier mode, i.e., coherent or noncoherent, as specified in the SHO or OPM-03.

9.5.3.15 KSA1 Shuttle Return

# of Bytes	Data Item
28	SA/SMAR Subheader No. 1
57	SA/MA/SMA ODM Subheader No. 8
1	Autotrack Status 0 = Disabled 1 = No signal presence indication 2 = Signal presence - no zero crossing 3 = Zero crossing - both axes 4 = Autotrack - fine pointing mode (1–3: Search Mode; 1–4: Enabled)
1	Receiver Coherency Indicator* 0 = Noncoherent 1 = Coherent
1	Doppler Tracking Status 0 = Inactive 1 = One-way 2 = Two-way
1	HDRR Lock Indication for Mode 1 0 = No Lock 1 = Lock
5	Spare
1	IR Lock Indication for Mode 1 or Mode 2 0 = No Lock 1 = Lock
5	IR Signal Strength Indication for Mode 1 or Mode 2 C/N_o (LSB = 0.1 dB-Hz)**
1	Symbol Synchronizer Lock Indication - Mode 1 or Mode 2, Channel 1 0 = No Lock 1 = Lock

* This is an indicator of the user's carrier mode, i.e., coherent or noncoherent, as specified in the SHO or OPM-03.

** When the IR E_b/N_o estimate exceeds 12 dB, the reported C/N_o will be a minimum.

# of Bytes	Data Item
1	Symbol Synchronizer Lock Indication - Mode 1 or Mode 2, Channel 2* 0 = No Lock 1 = Lock
1	Symbol Synchronizer Lock Indication - Mode 1, Channel 3 0 = No Lock 1 = Lock
1	BER Status - Mode 1, Channel 3 0 = Status not valid 1 = BER $\geq 10^{-3}$ 2 = 10^{-3} > BER $\geq 10^{-4}$ 3 = 10^{-4} > BER $\geq 10^{-5}$ 4 = 10^{-5} > BER $\geq 10^{-6}$ 5 = 10^{-6} > BER $\geq 10^{-7}$ 6 = 10^{-7} > BER $\geq 10^{-8}$ 7 = 10^{-8} > BER $\geq 10^{-9}$ 8 = BER < 10^{-9}
1	Data Format Conversion Configuration - Mode 1 or Mode 2, Channel 1 0 = No 1 = Yes
1	Data Format Conversion Configuration - Mode 1 or Mode 2, Channel 2 0 = No 1 = Yes
1	Data Format Conversion Configuration - Mode 1, Channel 3 0 = No 1 = Yes

* For 1.024 MHz Subcarrier, the IR Lock Indication is for the 1.024 MHz Carrier, not the data, and DQM data is not applicable.

# of Bytes	Data Item
1	Shuttle Mode 1 = Mode 1 2 = Mode 2, Channel 3-Digital 3 = Mode 2, Channel 3-Analog 4 = Mode 2, Channel 3-TV
9	Spare
117	

9.5.3.16 Deleted

9.5.3.17 KSA2/KaSA2 DG1 Return

This ODM structure is the same as that for KSA1/KaSA1 DG1 return (9.5.3.13), except that the service support subtype in Subheader No. 1 equals 4 or 7 as applicable.

9.5.3.18 KSA2/KaSA2 DG2 Return

This ODM structure is the same as that for KSA1/KaSA1 DG2 return (9.5.3.14), except that the service support subtype in Subheader No. 1 equals 4 or 7 as applicable.

9.5.3.19 KSA2 Shuttle Return

This ODM structure is the same as that for KSA1 shuttle return (9.5.3.15), except that the service support subtype in Subheader No. 1 equals 4.

9.5.3.20 Deleted

9.5.4 MA/SMAF ODM Header

The structure of the MA/SMAF ODM Header is:

Byte #	# of Bytes	Data Item
23-24	2	Message Types 1 = Tracking Data 2 = SHO - Routine 3 = OPM (Operations Messages) 4 = SLR (TDRSS Service Level Status) 5 = SA/SMAR Operations Data => 6 = MA/SMAF Operations Data 7 = End-to-End Test Operations Data 8 = SHO - Periodic
25-31	7	ODM ID The ID is a seven digit number. ODM's shall be sequentially numbered in the order sent, 1 to 9,999,999 to 1

Byte #	# of Bytes	Data Item
32	1	Spare
33	1	TDRS ID A = TDRS 1300 B = TDRS 1301 C = TDRS 1302 D = TDRS 1303 E = TDRS 1304 F = TDRS 1305 G = TDRS 1306 H = TDRS 1307 I = TDRS 1308 J = TDRS 1309
		TDRS Orientation (Defined in Section 9.5)
34-37	4	Angle 1-Yaw (0-360°, to accuracy of 0.25°) LSD = 0.1
38-41	4	Angle 2-Roll (0-360°, to accuracy of 0.1°) LSD = 0.1
42-45	4	Angle 3-Pitch (0-360°, to accuracy of 0.1°) LSD = 0.1
		Time Tag:
46-47	2	Year
48-50	3	Day
51-52	2	Hour
53-54	2	Minute
55-56	2	Second
57-58	2	Number of MA services reported in this ODM
59-66	8	Spare
	44	

9.5.5 MA/SMA ODM's

An MA/SMAF ODM is made up of an MA/SMAF ODM header, followed by a series of data sets for the active MA/SMA Forward or Return MA services. For TDRS H, I, and J, only SMAF is applicable. SMAR ODMs are provided within SA ODM structures.

9.5.5.1 MA/SMA Forward

# of Bytes	Data Item
1	Service Support Type 0 = Forward 1 = Return
7	Support Identifier Code (SUPIDEN)
2	Vehicle Identification Code (VIC)
3	Spare
	RF Beam Pointing: (Defined in Section 9.5)
4	Azimuth ($\pm 90^\circ$) Sign, 3 Digits (LSD = 0.1°)
4	Elevation ($\pm 90^\circ$) Sign, 3 Digits (LSD = 0.1°)
4	Signal EIRP** Sign, 3 Digits (LSD = 0.1 dBw)
10	Radiated Carrier Frequency*** (LSD = 10 Hz)

* Not used.

** Signal EIRP shall be obtained from a table look-up. The table shall be periodically updated, whenever the analogous table for PDA settings for the forward power mode is updated.

*** Radiated Carrier Frequency shall be set to the carrier frequency calculated for Doppler compensation and inhibit.

# of Bytes	Data Item
1	Link Status 0 = Active Status will be active during the following conditions: a. Forward service is set-up and running b. Return service has achieved link lock 1 = Pending (equipment unavailable for service) Status will be pending during the following conditions: a. Both prime and redundant equipment required for this support are FAILED b. No TTC look angles available for antenna service c. No USS doppler correction d. Equipment not configured/reconfigured (event processing error) 2 = Acq/reacq (service is being initiated/ reinitiated/reconfigured) Status will be acq/reacq during the following conditions: a. Link lock has not been achieved for initiation of a return service b. Link lock is not achieved for a return service recovering from a PENDING state c. Link lock is not achieved for a return service undergoing reconfiguration/reacquisition
1	Clock Presence (for all 5 seconds of the reporting interval) 0 = No 1 = Yes
2	Data Transition Density Percent Transitions (average of 5 one-second readings) 2 Digits (00 - 99)
39	

9.5.5.2 MA Return

# of Bytes	Data Item
1	Service Support Type 0 = Forward 1 = Return
7	Support Identifier Code (SUPIDEN) Section 11.
2	Vehicle Identification Code (VIC)
38	SA/MA/SMA ODM Subheader No. 8
2	MA Return Link ID (obtained from SHO)
6	Spare
	RF Beam Pointing: (Defined in Section 9.5)
4	Azimuth ($\pm 90^\circ$) Sign, 3 Digits (LSD = 0.1°)
4	Elevation ($\pm 90^\circ$) Sign, 3 Digits (LSD = 0.1°)
2	MA Return Link ID (ID of the MAR equipment string, including receiver.)
1	Doppler Tracking Status 0 = Inactive 1 = One-way 2 = Two-way 3 = Cross Support
1	Range Tracking Status 0 = Inactive 1 = Active 2 = Cross Support

# of Bytes	Data Item
1	Receiver Coherency Indicator 0 = Noncoherent 1 = Coherent
1	Data Format Conversion Configuration, I Channel 0 = No 1 = Yes
1	Data Format Conversion Configuration, Q Channel 0 = No 1 = Yes
3	I/Q Channel Power Ratio** Sign, 2 Digits, (LSD = 0.1 dB)
1	Symbol Format Conversion-BIϕ to NRZ, I Channel 0 = No 1 = Yes
1	Symbol Format Conversion-BIϕ to NRZ, Q Channel 0 = No 1 = Yes
1	Configuration 0 = I Channel only 1 = Q Channel only 2 = I and Q Channel
1	IR Lock Indicator 0 = No Lock 1 = Lock
5	IR Signal Strength Indication C/N_o*** (LSB = 0.1 dB-Hz)

* Not used.
** I/Q Channel Power Ratio will be ASCII Space when BPSK is used.
*** When the I and Q Channel BER Status equals 7 or 8, the reported C/N_o will be a minimum.

# of Bytes	Data Item

1	Symbol Synchronizer Lock Indication, I Channel 0 = No Lock 1 = Lock	
1	Symbol Synchronizer Lock Indication, QChannel 0 = No Lock 1 = Lock	
1	BER Status-I Channel 0 = Status not valid 1 = BER $\geq 10^{-3}$ 2 = 10^{-3} > BER $\geq 10^{-4}$ 3 = 10^{-4} > BER $\geq 10^{-5}$ 4 = 10^{-5} > BER $\geq 10^{-6}$ 5 = 10^{-6} > BER $\geq 10^{-7}$ 6 = 10^{-7} > BER $\geq 10^{-8}$ 7 = 10^{-8} > BER $\geq 10^{-9}$ 8 = BER < 10^{-9}	
1	BER Status-Q Channel 0 = Status not valid 1 = BER $\geq 10^{-3}$ 2 = 10^{-3} > BER $\geq 10^{-4}$ 3 = 10^{-4} > BER $\geq 10^{-5}$ 4 = 10^{-5} > BER $\geq 10^{-6}$ 5 = 10^{-6} > BER $\geq 10^{-7}$ 6 = 10^{-7} > BER $\geq 10^{-8}$ 7 = 10^{-8} > BER $\geq 10^{-9}$ 8 = BER < 10^{-9}	
1	Data Channel Configuration 0 = Single 1 = Dual (I and Q)	
1	Link Status 0 = Active Status will be active during the following conditions: a. Forward service is set-up and running b. Return service has achieved link lock	

# of Bytes	Data Item
	1 = Pending (equipment unavailable for service) Status will be pending during the following conditions: a. Both prime and redundant equipment required for this support are FAILED b. No TTC look angles available for antenna service c. No USS doppler correction d. Equipment not configured/reconfigured (event processing error)
	2 = Acq/reacq (service is being initiated/ reinitiated/reconfigured) Status will be acq/reacq during the following conditions: a. Link lock has not been achieved for initiation of a return service b. Link lock is not achieved for a return service recovering from a PENDING state c. Link lock is not achieved for a return service undergoing reconfiguration/reacquisition
1	Spare
1	Mode 1 = Mode 1 2 = Mode 2
1	G2 Inversion-I Channel* 0 = Not inverted 1 = Inverted
1	G2 Inversion-Q Channel* 0 = Not inverted 1 = Inverted
93	

* G2 Inversion will be ASCII Space when channel is not used, e.g., BPSK.

9.5.6 End-to-End Test ODM Header

The structure of the End-to-End Test header is:

Byte #	# of Bytes	Data Item
23-24	2	Message Types 1 = Tracking Data 2 = SHO - Routine 3 = OPM (Operations) 4 = SLR (TDRSS Service Level Status) 5 = SA Operations Data 6 = MA Operations Data => 7 = End-to-End Test Operations Data 8 = SHO - Periodic
25-31	7	ODM ID The ID is seven digit number. ODM's shall be sequentially numbered in the order sent, 1 to 9,999,999 to 1.
32	1	Spare (ASCII Space)
33	1	TDRS ID A = TDRS 1300 B = TDRS 1301 C = TDRS 1302 D = TDRS 1303 E = TDRS 1304 F = TDRS 1305 G = TDRS 1306 H = TDRS 1307 I = TDRS 1308 J = TDRS 1309
		TDRS Orientation (Defined in Section 9.5)
34-37	4	Angle 1-Yaw (0-360°, to accuracy of 0.25°) } LSD = 0.1
38-41	4	Angle 2-Roll (0-360°, to accuracy of 0.1°) } LSD = 0.1
42-45	4	Angle 3-Pitch (0-360°, to accuracy of 0.1°) } LSD = 0.1
		Time Tag:
46-47	2	Year
48-50	3	Day
51-52	2	Hour
53-54	2	Minute
55-56	2	Second
57-58	2	Number of End-to-End Test services reported in this ODM.
	36	

9.5.7 End-to-End Test ODM Subheader

The structure of this subheader is:

# of Bytes	Data Item
1	Service Support Type 0 = Forward 1 = Return
7	Support Identifier Code (SUPIDEN)
2	Vehicle Identification Code (VIC)
1	Service Support Subtype/Configuration 0 = MA 1 = SSA 2 = KSA 3 = S-Band Shuttle 4 = K-Band Shuttle 5 = SMA
1	Antenna Polarization 0 = LCP 1 = RCP
1	Spare
3	Spare
16	

9.5.8 End-to-End Test ODM's

These messages are made up of an End-to-End Test ODM header followed by a series of End-to-End Test ODM subheaders and data sets for the active end-to-end test services: i.e., simultaneous forward, return and tracking for one SSA and one KSA (including Shuttle) or for one MA and one KSA for each SGLT. The requirement for one SSA or one MA shall be interpreted to mean one S-Band forward, return, and tracking, and shall include cross support testing. ODM's for the end-to-end test forward, return, and tracking services are as described in Section 9.5.1 through 9.5.5.

9.5.8.1 End-to-End Test ODM, Forward

# of Bytes	Data Item
16	End-to-End Test ODM subheader
4	Simulation G/T Sign, 3 Digits (LSD = 0.1 dB/°K)
10	Forward Link Frequency, (LSD = 10 Hz)*
1	Command Channel Lock** 0 = No Lock 1 = Lock
1	Carrier Lock (PTE Demodulator) 0 = No Lock 1 = Lock
1	Bit Sync Lock*** 0 = No Lock 1 = Lock
1	Spare

* This is the radiated carrier frequency. It is a repeat of the same parameter in SA ODM Subheader No. 2.

** Command Channel Lock is an indication of a lock/no lock condition for the command channel PN code, i.e., the Gold code of length 2^{10} - 1 chips. This data item is not applicable (ASCII space) for command rates >300 kbps.

*** Bit Sync Lock is an indication of a lock/no lock condition of the bit synchronizer for the modulation on the command channel. This data item is applicable at all command data rates.

# of Bytes	Data Item
1	BER Status*
	0 = Status not valid
	1 = BER $\geq 10^{-3}$
	2 = 10^{-3} > BER $\geq 10^{-4}$
	3 = 10^{-4} > BER $\geq 10^{-5}$
	4 = 10^{-5} > BER $\geq 10^{-6}$
	5 = 10^{-6} > BER $\geq 10^{-7}$
	6 = 10^{-7} > BER $\geq 10^{-8}$
	7 = 10^{-8} > BER $\geq 10^{-9}$
	8 = BER < 10^{-9}
1	Spare
36	

9.5.8.2 End-to-End Test ODM, Return

# of Bytes	Data Item
16	End-to-End Test ODM Subheader
4	Simulated EIRP
	Sign, 3 Digits (LSD = 0.1 dBw)
10	Return Link Frequency, (LSD = 10 Hz)***
2	Spare
32	

* This BER Status is valid only for locally generated End-To-End Test data.
** Not used.
*** For non-coherent services this is the RF frequency transmitted from the End-to-End Test Antenna. For coherent services this is N/A.

Section 10. Polynomial Encoding and Decoding

10.1 Polynomial Encoding

Polynomial encoding a data block consists of 1) dividing a message polynomial, M(x), by a generator polynomial, G(x), 2) discarding the resulting quotient, and 3) transmitting the resulting remainder polynomial, R(x), along with M(x).

For the 4800-bit data block, the message bits to be encoded (i.e., Bits 25 through 4776) are treated as coefficients of a polynomial, M(x), with a dummy variable, x, and having the highest order term as [Bit 25] x 4751. The message polynomial is defined as:

$$M(x) = x^{22} [m(x)]$$

The message polynomial is modulo 2 divided by the generator polynomial, where G(x) is defined as:

$$G(x) = x^{22} + x^{20} + x^{14} + x^{13} + x^{12} + x^{11} + x^{8} + x^{7} + x^{5} + x^{3} + x + 1$$

The results of this division provides a 22-bit remainder which is treated as a 21st degree polynomial, R(x), with coefficients corresponding to the 22-bit remainder.
The remainder polynomial is added to the message polynomial for transmission. This sum polynomial, M(x) + R(x), is integrally modulo 2 divisible by G(x), (i.e., provides a remainder of zero).

NOTE

In the encoding process, the two flag bits (Bits 4777 and 4778) are "bypassed."

10.2 Polynomial Decoding

Polynomial decoding the received encoded data block consists of dividing [M(x) + R(x)] by G(x). In the absence of errors (i.e., M(x) + R(x) = M(x) +R(x)), the remainder of this division will be 22 zeroes. If the remainder is nonzero, error(s) have occurred in M(x) + R(x) during transmission.

NOTE

In the decoding process, the two flag bits (Bits 4777 and 4778) are "bypassed."

Section 11. Support Identifier Code (SUPIDEN)

The SUPIDEN consists of a maximum of seven alphanumeric characters. The characters are divided into three groups as follows:

a. The first character (class) (position one) is always alpha and will indicate the parent organization having project management responsibility or the requestor of support for a particular activity.

NOTE

This character may change if an organization requests the STDN to support a spacecraft whose project management responsibility belongs to another organization. For example, Mariner support by the STDN at the request of the Jet Propulsion Laboratory (JPL) would be prefaced by a J, but a tracking experiment by the Networks Division using Mariner (with the concurrence of JPL) might indicate a G.

b. The next four characters, Support Identification Code (SIC) (positions two through five), are always numeric and identify the particular spacecraft or activity being supported. Once assigned in the early planning stages, these numeric characters will never change throughout the life of a mission. That is to say, from the original assignment of a designation throughout the support lifetime until the termination of support for this mission, the numeric designation will never change.

c. The last two characters (function) (positions six and seven) are alphanumeric and describe the major type of support being provided or referenced.

An example of a completed support identifier code for SAS-3 orbital support is:

A1041MS
A - Goddard Mission Operations Division (requestor)
1041-SAS-3 Spacecraft Designation
MS - Mission Support (orbital)

NOTE

If two titles are given, the first title will be the official title and the second title will be given for information purposes only.

Section 12. Tracking Service Data

12.1 Tracking Service Data Format

12.1.1 General

The user spacecraft tracking service data parameters identified in Table 12-1 of this section shall be transmitted from the STGT to the FDF, JSC and LI. The TDRS tracking service data parameters identified in paragraph 12.1.5 shall be transmitted from the STGT to the FDF. The staleness of data provided by the SGLT at the DIS shall not exceed five seconds relative to the time of measurement.

Each tracking data sample shall be formatted in accordance with the NASA Universal Tracking Format. All tracking data messages shall consist of one or more standard NASA/STGT 4800-bit blocks, with each block containing at least one tracking data sample in the data field of the block. Formatting the tracking data for transmission requires generating a 4800-bit block which consists of a network control header, a TDRSS header for FDF and LI TDMs, a unique TDRSS header for JSC TDMs, a time field, a data field, and an error control field. The bytes of the tracking data samples for JSC TDMs shall be formatted LSB first. The time field and the error control field shall be set to a logical one state by the SGLT. The format of the unique TDRSS header for TDMs destined for JSC is shown below:

Bit						Bit
49	01_{16}				01_{16}	64
65	Message Type - MSB 213				01_{16}	80
81	0	0	0	Number of Bits in Data Field		96

Table 12-1 defines the message format and fields for the STGT tracking service data message.

12.1.2 Tracking Data Destination

All user tracking data shall be sent to the LI. All user tracking data, designated by predefined Support Identification Codes (bytes 7-8 of Table 12-1), shall be sent to the FDF and JSC and shall be logged. TDRS tracking data (defined in paragraph 12.1.5) shall be sent to the FDF. Tracking data sent to the LI shall not be recorded.

12.1.3 Ground Rules

The following ground rule applies to tracking service data messages:

a. Acknowledgment of message receipt from the FDF is not required.

12.1.4 Data Field Description

A description of each data field in the tracking sample is given below:

a. Message Leader. Bytes 1-5 are constants used to conform to the NASA Universal Tracking format.

b. Current Year. The contents of this field (byte 6) shall be the two least significant digits of the current year. The Least Significant Bit (LSB) equals 1 year.

Table 12-1. TDRSS Tracking Data Service

BYTE	BYTE FORMAT	# OF BITS	BYTE CONTENTS
1	HEXADECIMAL	8	OD_{16}
2	HEXADECIMAL	8	OA_{16}
3	HEXADECIMAL	8	$O1_{16}$
4	HEXADECIMAL	8	41_{16}
5	HEXADECIMAL	8	41_{16}
6	BINARY	8	CURRENT YEAR
7-8	BINARY	16	SUPPORT IDENTIFICATION CODE (SIC)
9-10	BINARY	16	VEHICLE IDENTIFICATION CODE (VIC)
11-14	BINARY	32	TIME TAG (SECONDS OF YEAR)
15-18	BINARY	32	TIME TAG (MICROSECONDS OF SECOND)
19-22	BINARY	32	RETURN LINK GROUND ANTENNA ANGLE AXIS NO. 1 (AZIMUTH)
23-26	BINARY	32	RETURN LINK GROUND ANTENNA ANGLE AXIS NO. 2 (ELEVATION)
27-32	BINARY	48	RANGE (ROUND TRIP LIGHT TIME)
33-38	BINARY	48	DOPPLER COUNT
39-40	HEXADECIMAL	16	00_{16} (EACH BYTE)
41-44	BINARY	32	REFERENCE FREQUENCY
45	HEXADECIMAL	8	60_{16}
46	BINARY	8	FORWARD LINK GROUND ANTENNA I.D.
47	HEXADECIMAL	8	60_{16}
48	BINARY	8	RETURN LINK GROUND ANTENNA I.D.
49	BINARY	8	TDRS I.D.'s (FORWARD AND RETURN LINK)
50	BINARY/DISCRETE	8	MA RETURN LINK I.D., TDRS TRACKING DATA ONLY INDICATOR, TRACKING SERVICE CONFIGURATION
51	DISCRETE	8	DATA VALIDITY
52	HEXADECIMAL	8	FREQUENCY BAND AND SERVICE TYPE

Table 12-1. TDRSS Tracking Data Service (Cont'd)

BYTE	BYTE FORMAT	# OF BITS	BYTE CONTENTS
53-54	HEXADECIMAL/ DISCRETE/BINARY	16	TRACKER TYPE, END OF TRACK, AND SAMPLE RATE
55	DISCRETE/BINARY	8	SERVICE LINK I.D., SINGLE ACCESS TDRS/GROUND TERMINAL CARRIER FREQUENCY I.D., TDRS AND RF BEAM ORIENTATION DATA VALIDITY
56	DISCRETE/BINARY	8	NASA GROUND-BASED TDRS TRACKING DATA TRANSPONDER I.D., USER BIT RATE INDICATOR
57-62	BINARY	48	TDRS ORIENTATION
63-68	BINARY	48	TDRS RF BEAM ORIENTATION
69	BINARY	6	STATUS BITS FOR PN LOCK, CARRIER LOCK, DOPPLER COMPENSATION, SGLT, SA EQUIPMENT STRING
69	BINARY	2	00_{16}, SPARE BITS
70-72	HEXADECIMAL	24	00_{16} (EACH BYTE), SPARES
73	HEXADECIMAL	8	04_{16}
74	HEXADECIMAL	8	OF_{16}
75	HEXADECIMAL	8	OF_{16}

c. Support Identification Code. The contents of this field (bytes 7-8) shall be the SIC, or the Support Identification Code of the TDRS providing the return link service when the user is a NASA ground-based transponder. The SIC will be assigned by NASA.

d. Vehicle Identification Code. The contents of this field (bytes 9-10) shall be the vehicle identification code assigned by NASA. The combination of SIC and vehicle identification code will be unique for each user or TDRS as described in c. above.

e. Time Tag. The contents of these fields shall be a multiple of the sample rate and shall be the seconds of year (bytes 11-14) and the microseconds of the second (bytes 15-18). Time for seconds of the year is referenced to 00:00:00.0 January 1 of the current year. The LSB of byte 14 equals one second. The LSB of byte 18 equals one microsecond.

f. Return Link Ground Antenna Angle. The contents of these fields (bytes 19-22 and bytes 23-26) shall be the ground antenna angles associated with the return link providing the tracking service. Azimuth shall be measured in the local horizontal plane positive clockwise from north. The local horizontal plane is defined to be perpendicular to the local gravitational vertical. Elevation shall be measured positive above local horizontal. The resolution of each angle shall be 0.0055°. These angles shall be reported to the FDF with an uncertainty $\leq$ 0.03°. The angles in both fields shall be represented by fractions of a circle. For both fields, the LSB equals $360.\overline{0}°$x2-32 and the Most

Significant Bit (MSB) equals $180.\overline{0}°$. Bytes 19-22 shall contain azimuth. Bytes 23-26 shall contain elevation.

g. Range. The contents of this field (bytes 27-32) shall be the range measurement (round trip light time) to a resolution of one nanosecond. The LSB of this field equals 2-8 nanosecond.

h. Doppler Count. The contents of this field (bytes 33-38) shall be the count of the Doppler counter. The LSB of this field equals one cycle of the biased Doppler signal ($240.\overline{0}$ MHz + 1000 fd for S-Band and $240.\overline{0}$ MHz + 100 fd for Ku-Band). The count shall be cumulative for the duration of the tracking service.

i. Byte 39. Constant (00_{16}).

j. Byte 40. Constant (00_{16}).

k. Reference Frequency. The contents of this field (bytes 41-44) shall be the frequency used for Doppler extraction. The LSB of this field equals 10 Hz, which is the required resolution of the reference frequency.

   The tracking reference frequency shall be included in all tracking data frames, regardless of the range and Doppler validity status. During periods of Doppler compensation, the frequency provided shall be the current actual frequency, applicable within 0.1 seconds of the tracking frame time tag. If Doppler compensation is not required, the tracking reference frequency shall be available at least 2 seconds before the scheduled service start.

l. Byte 45. Constant (60_{16}).

m. Forward Link Ground Antenna ID. The contents of this field (byte 46) shall be the STGT/WSGTU ground antenna ID associated with the TDRS which is providing the forward link for the tracking service. The ground antenna IDs as defined by NASA are:

WSGTU ID	STGT ID	Ground Antenna
0	0	None (for one-way tracking service)
9	47	North antenna
10	48	Central antenna
11	49	South antenna
33	25	S-Band antenna

n. Byte 47. Constant (60_{16}).

o. Return Link Ground Antenna ID. The contents of this field (byte 48) shall be the STGT/WSGTU ground antenna ID associated with the TDRS which is providing the return link for the tracking service. The ground antenna IDs are:

WSGTU ID	STGT ID	Ground Antenna
9	47	North antenna
10	48	Central antenna
11	49	South antenna
33	25	S-Band antenna

p. TDRS IDs. The contents of this field (byte 49) shall be the 4-bit identification of the TDRS providing the forward link and 4-bit identification of the TDRS providing the return link for the tracking service.

NASA has defined a unique Support Identification Code (SIC) for each TDRS as follows:

TDRS-A : 1300
TDRS-B : 1301
TDRS-C : 1302
. .
. .
. .
TDRS-J : 1309

The STGT shall perform a transformation from the SIC to a unique 4-bit code for each TDRS. The transformation shall be:

SIC minus 1299 equals unique 4-bit TDRS ID:

TDRS-A : 1
TDRS-B : 2
TDRS-C : 3
. .
. .
. .
TDRS-J : 10

The contents of this field shall be as defined below:

Field Location	Contents
Bits 5-8	Forward link TDRS ID, 0_{16} shall indicate forward link not supporting. The LSB is Bit 5.
Bits 1-4	Return link TDRS ID, 0_{16} will not be used. The LSB is Bit 1.

q. MA Return Link ID, TDRS Tracking Data Only Indication, and Tracking Service Configuration. The contents of this field (byte 50) shall be an identification of the MA return link supporting the tracking service, an indication if STGT is providing tracking service to the NASA ground-based TDRS tracking data transponders that are identified in byte 56, and the configuration of the tracking service.

The contents of this field shall be as defined below:

Field Location	Contents		
Bits 4-8	MA return link ID; binary ID of the MAR equipment string (including receiver), providing the tracking service. Binary zero shall indicate MA return link not supporting. The LSB is Bit 4.		
Bit 3	TDRS tracking data only indication. Bit 3 is zero when: 1309 < User SIC < 1373; otherwise: Bit 3 is one.		
Bits 1-2	Tracking service configuration		
	Bit 2	Bit 1	
	0	1	Return link only (no forward link established to user)
	1	0	Forward and return link established by this TDRS
	1	1	Spare
	0	0	Spare

r. Data Validity. The contents of this field (byte 51) shall indicate the validity of the contents of the range field (bytes 27-32), the Doppler count field (bytes 33-38), and the return link antenna angle fields (bytes 19-26).

Two-way Doppler data is valid if:

1. Associated receiver has indicated carrier track at each sample point (once/second) throughout last tracking sample period.
2. Forward Doppler compensation has been inhibited; i.e., the slow and hold function has been completed and the forward frequency is fixed.
3. The associated IR is not exhibiting a fault indication.

One-Way Doppler data is valid if:

1. Associated receiver has indicated carrier track at each sample point (once/second) throughout last tracking sample period.
2. The associated IR is not exhibiting a fault indication.

Antenna angles are valid if:

1. Antenna is in autotrack mode.
2. Antenna is not exhibiting a major fault or a control fault.
3. Antenna measurements are on time (i.e., there was a measurement received corresponding to the 1 pps read tic).

Range data will be valid if:

1. The receiver used for the associated return service has PN lock.
2. The IR used for the tracking service is not exhibiting a fault.
3. The timing distribution amplifier for the associated IR is not exhibiting a fault.
4. A forward service is scheduled.

The contents of this field shall be as listed below:

Field Location	Contents
Bits 4-8	0
Bit 3	Ground Antenna Validity of the data in bytes 19-26 1 - valid 0 - not valid
Bit 2	Doppler validity 1 - valid 0 - not valid
Bit 1	Range validity 1 - valid 0 - not valid

s. Frequency Band and Service Type. The contents of this field (byte 52) shall be the frequency band of the forward link and/or the return link of the user being provided the tracking service, and the type of service for which tracking service is being provided.

The contents of this field shall be as defined below:

Field Location	Contents
MSD	Frequency Band 3_{16} - S-Band 6_{16} - Ku-Band
LSD	Service Type 1_{16} - Not used 2_{16} - End-to-End Test service 4_{16} - Normal service

t. Tracker Type, End of Track and Sample Rate. The contents of this field (bytes 53-54) shall be the tracker type code for TDRSS, an end of track (EOT) indication, and the rate at which the tracking data is sampled.

The contents of this field shall be as defined below:

Field Location	Contents
Byte 53, Most Significant Digit (MSD)	Tracker type 7_{16} - indicated TDRSS tracking service.
Byte 53, Bit 4	End of track 1 - indicates the sample is the last to be transmitted (i.e., at the end of the scheduled service support period, otherwise a 0).
Byte 53, Bit 3	0 - indicates data in sample rate field is seconds between tracking samples.
Byte 53, Bit 2 through Byte 54, Bit 1	Sample rate - binary seconds between tracking samples. The LSB (byte 54, bit 1) equals 1 second.

u. Service Link ID, Single Access TDRS/Ground Terminal Carrier Frequency ID, TDRS and RF Beam Orientation Validity. The contents of this field (byte 55) shall be the identification of the forward and/or return links providing the tracking service, an identification of the TDRS/ground terminal (GT) carrier frequency(ies) utilized for the SA forward and/or return links providing the tracking service, and the validity of the TDRS and RF beam orientation data provided in bytes 57-62 and 63-68.

Given the coordinate definitions

+z = local vertical to earth,

+x = positive roll axis (forms right-handed set with y and z),

+y = positive pitch axis (parallel to solar array rotational axis and pointed toward SGL antenna side of spacecraft).

SA antenna link 1 is the steerable antenna on the +x axis, SA antenna link 2 is the steerable antenna on the -x axis.

The TDRS/GT carrier frequencies are defined as:

S forward carrier frequency 1 : 14679.5 MHz
S forward carrier frequency 2 : 14719.5 MHz
K forward carrier frequency 1 : 14625.0 MHz
K forward carrier frequency 2 : 15200.0 MHz
S return carrier frequency 1 : 13677.5 MHz
S return carrier frequency 2 : 13697.5 MHz
K return carrier frequency 1 : 13528.4 MHZ
K return carrier frequency 2 : 13928.4 MHz

For forward links and for S-Band return links, carrier frequency 1 shall be hardwired to link 1 and carrier frequency 2 shall be hardwired to link 2. For K-Band return, link 1 may be associated with either carrier frequency, as may link 2. An SSA1 or KSA1 tracking service shall correspond to link 1. An SSA2 or KSA2 tracking service shall correspond to link 2.

TDRS Orientation and RF Beam Orientation will be valid if Telemetry frame synchronization has been achieved for the frame(s) containing Attitude Control System (ACS) data from which TDRSS orientation in the Tracking sample is computed.

The contents of this field shall be as defined below:

Field Location	Contents
Bit 8	TDRS Orientation Data Validity (see bytes 57-62) 1 - valid 0 - not valid
Bit 7	RF Beam Orientation Data Validity (see bytes 63-68) 1 - valid 0 - not valid
Bit 6 Bit 5 Bit 4	Forward Link ID and TDRS/GT Carrier Frequency ID
0 0 0	Forward Link not supported by this TDRS providing the return link service
0 0 1	SA Link 1, TDRS/GT Carrier Frequency 1
0 1 0	Spare
0 1 1	MA
1 0 0	Spare
1 0 1	Spare
1 1 0	SA Link 2, TDRS/GT Carrier Frequency 2
1 1 1	Spare

Field Location			Contents
Bit 3	Bit 2	Bit 1	Return Link ID and TDRS/GT Carrier Frequency ID
0	0	0	Spare
0	0	1	SA Link 1, TDRS/GT Carrier Frequency 1
0	1	0	SA Link 2, TDRS/GT Carrier Frequency 1
0	1	1	MA
1	0	0	Spare
1	0	1	SA Link 1, TDRS/GT Carrier Frequency 2
1	1	0	SA Link 2, TDRS/GT Carrier Frequency 2
1	1	1	Spare

v. NASA Ground-Based TDRS Tracking Data Transponder ID and User Bit Rate (BR) Indicator. The contents of this field (byte 56) shall be the identification of the NASA ground-based tracking data transponder which NASA will utilize to obtain TDRS tracking data, and an indicator to designate the telemetry bit rate group of the user for which the return link service is being provided. When support is to a ground-based transponder, the SGLT shall perform a transformation from SIC to unique code for this field. The transformation shall be: If 1309 < SIC < 1373 this field is set to SIC minus 1309. Otherwise this field is set to 00.

The contents of this field shall beas defined below:

Field Location		Contents
Bit 8	Bit 7	User BR
0	0	5000 bps < BR
0	1	1000 bps < BR $\leq$ 5000 bps
1	0	500 bps < BR $\leq$ 1000 bps
1	1	BR $\leq$ 500 bps
Bit 1-6		Bits 1-6 shall be zero when: 1309 $\geq$ User SIC, or User SIC $\geq$ 1373 Otherwise: Bits 1-6 shall contain the results of subtracting 1309 from the User SIC

w. TDRS Orientation. The contents of this field (bytes 57-62) shall be the orientation of the corrected local TDRS coordinate system relative to the NASA defined coordinate system for the TDRS providing the return link for the tracking service.

The corrected local TDRS coordinate system has its origin at the spacecraft center-of-mass, the Z-axis along the spacecraft longitudinal centerline, the Y-axis parallel to the solar array rotational axis and pointed toward the SGL antenna side of the spacecraft, and the X-axis completing the right-handed set. The NASA defined coordinate system has its origin at the spacecraft center-of-mass, the Z-axis in the orbit plane pointed toward nadir, the X-axis in the orbit plane pointed in the direction of spacecraft orbital motion, and the Y-axis completing the right-handed set.

The TDRS orientation parameters will be given as Euler angles transforming the NASA defined coordinate system to the corrected local TDRS coordinate system, given by the following order of rotations: Yaw, a right-handed rotation about the Z NASA-system axis; followed by roll, a right-handed rotation about the resultant X-axis; followed by pitch, a right-handed rotation about the resultant Y-axis.

Field Location	Contents
Bytes 57-58	Yaw
59-60	Roll
61-62	Pitch

For each angle, the MSB shall be $180.\overline{0}^\circ$, the LSB shall be $360.\overline{0}^\circ \times 2^{-16}$, and the resolution shall be $.0055^\circ$. The accuracy shall be 0.1° in pitch and roll and 0.25° in yaw.

x. <u>TDRS RF Beam Orientation</u>. The contents of this field (bytes 63-68) shall be the orientation of the RF beam for the return link providing the tracking service. The orientation shall be relative to the corrected local TDRS coordinate system.

The RF Beam Orientation parameters will be given as azimuth and elevation relative to the corrected local TDRS coordinate system defined in w. above, by the following order of rotations: azimuth, a right-handed rotation about the Y TDRS-body axis, followed by elevation, a right-handed rotation about the resultant X-axis.

Bytes 63-65 shall contain the azimuth and bytes 66-68 shall contain the elevation. The LSB of each shall be $90.\overline{0}^\circ \times 2^{-23}$, the resolution shall be $90.\overline{0}^\circ \times 2^{-23}$, the range shall be $\pm 90^\circ$, and negative values shall be expressed in ones complement form. The accuracy of the data shall be 0.5° for an SA service and 2° for an MA service.

y. <u>Status Bits and Equipment Configuration</u>. The contents of this field (byte 69, bits 3 through 8) shall be the status of Doppler compensation, PN lock, and carrier lock and shall indicate the SGLT and SA equipment string in use. All of the status bits are to be implemented on all associated frames immediately following any system status change, reconfiguration, or equipment failover.

Byte 69, bits 3 through 8 are defined as follows:

Bit	Value	Description
8		Doppler Compensation
	0	On
	1	Off
7		PN lock at receiver
	0	Out of lock
	1	In lock
6		Carrier lock at receiver
	0	Out of lock
	1	In lock
5-4		SGLT
	00	N/A
	01	SGLT-1
	10	SGLT-2
	11	SGLT-3
3		SA Equipment String
	0	A
	1	B

The Doppler compensation status bit shall remain 0 (on) during the slow-and-hold interval and be changed to 1 (off) on the frame following frequency stabilization. The Doppler compensation status bit shall also be set to 0 (on) during an expanded frequency search and reset to 1 (off) on the frames immediately following frequency stabilization.

12.1.5 TDR Spacecraft Tracking

The NCC will provide Tracking and Data Relay (TDR) Spacecraft specific schedules to STGT for initiating tracking and gathering and transmitting TDR Spacecraft tracking data.

12.1.5.1 Tracking Schedules

The tracking schedules shall be of two types, generic and specific, and shall be forwarded to STGT through administrative means (i.e., the schedule is not processed by STGT ADPE).

a. Generic Schedules. The generic schedule will incorporate the following classes:

- routine operations (e.g., 5 minutes every hour on the hour at a 1 per 10 seconds sample rate).
- supplemental support (e.g., 1 minute every eighth hour on the hour at a 1 per second sample rate).
- maneuver support (e.g., 10 minutes each half hour on the half hour and hour for 6 hours at a 1 per 10 seconds sample rate).

b. Specific Schedule. A specific schedule shall be requested for support under special conditions, such as testing. It shall contain a specific list of event times.

12.1.5.2 Schedule Parameters

The following schedule parameters shall be included in any schedule request and apply to each class on an individual TDR Spacecraft basis:

a. Duration of tracking event (e.g., 5 minutes, 10 minutes).

b. Frequency of tracking event (e.g., every half hour, every hour, every other hour).

c. Sample Rate during tracking event (e.g., 1 sample per second, 1 sample per 10 seconds).

d. Start time of first tracking event covered by schedule class.

e. Period of time, relative to the start time of the first event, for which schedule is applicable.

f. Vehicle Identification Code (VIC).

Procedures for schedule implementation, transition from one schedule class to another, transition to an updated schedule, preemption of scheduled events, schedule prioritization, schedule conflict resolution, and schedule deactivation shall be provided by the NCC. Schedule activation shall be supported by STGT ADPE.

12.1.5.3 Data Field Description for TDR Spacecraft Tracking Frames Data

A description of each data field in the TDR spacecraft tracking data sample is given in what follows (see Table 12-1a). Those fields that contain measurement data state the reporting resolution. This number tells the value represented by the Least Significant Bit of the field. The description also contains references to the resolution and accuracy of the measurement itself.

a. Frame Leader. Bytes 1-5 are constants used to conform to the NASA Universal Tracking format. Byte 1 is OD_{16}, Byte 2 is OA_{16}, Byte 3 is 01_{16}, and Bytes 4-5 are each 41_{16}.

b. Current Year. The contents of this field (byte 6) shall be the two least significant digits of the current year. The Least Significant Bit (LSB) equals 1year.

c. Support Identification Code. The contents of this field (bytes 7-8) shall be the Support Identification Code (SIC) of the TDRS being tracked. The SIC will be assigned by NASA.

d. Vehicle Identification Code. The contents of this field (bytes 9-10) is the Vehicle Identification Code (VIC). It shall be given a default value of 1. The VIC may be specified according to the type of TDRS-specific schedule from which the tracking event (routine, supplemental, maneuver, or specific) is derived.

e. Time Tag. The contents of this field shall be the seconds of year (bytes 11-14). Time for seconds of the year is referenced to 00:00:00.0 January 1 of the current year and is computed according to the rule

Time in Seconds = 86400 K + M,

where K is the number of full days which have elapsed since the beginning of the year and M is the number of seconds since the beginning of the day of track. The time tag shall be a multiple of the sample rate. The LSB of byte14 equals one second.

Table 12-1a. TDR Spacecraft Tracking Data Format

BYTE	BYTE FORMAT	NO. OF BITS	BYTE CONTENTS
1	HEXADECIMAL	8	OD_{16}
2	HEXADECIMAL	8	OA_{16}
3	HEXADECIMAL	8	$O1_{16}$
4-5	HEXADECIMAL	16	41_{16} (EACH BYTE)
6	BINARY	8	CURRENT YEAR
7-8	BINARY	16	SUPPORT IDENTIFICATION CODE(SIC)
9-10	BINARY	16	VEHICLE IDENTIFICATION CODE(VIC)
11-14	BINARY	32	TIME TAG (SECONDS OF YEAR)
15-18	BINARY	32	TIME TAG (MICROSECONDS OF SECOND, SET TO ZERO)
19-22	BINARY	32	RETURN LINK GROUND ANTENNA ANGLE AXIS NO. 1 (AZIMUTH)
23-26	BINARY	32	RETURN LINK GROUND ANTENNA ANGLE AXIS NO. 2 (ELEVATION)
27-32	BINARY	48	RANGE (ROUND TRIP LIGHT TIME)
33-38	HEXADECIMAL	48	00_{16} (EACH BYTE)
39-40	HEXADECIMAL	16	SPARES (EACH UNUSED BIT SET TO 0)
41-44	BINARY	32	FORWARD LINK FREQUENCY
45	HEXADECIMAL	8	FORWARD LINK GROUND ANTENNA SIZE & TYPE

Table 12-1a. TDR Spacecraft Tracking Data Format (Cont'd)

BYTE	BYTE FORMAT	NO. OF BITS	BYTE CONTENTS
46	BINARY	8	FORWARD LINK GROUND ANTENNA I.D.
47	HEXADECIMAL	8	RETURN LINK GROUND ANTENNA SIZE & TYPE
48	BINARY	8	RETURN LINK GROUND ANTENNA I.D.
49-50	DISCRETE	16	STATUS AND CONFIGURATION INDICATION
51	DISCRETE	8	SUBSYSTEM/DATA VALIDITY
52	HEXADECIMAL	8	FREQUENCY BAND AND SERVICE TYPE
53-54	HEXADECIMAL/ DISCRETE/BINARY	16	TRACKER TYPE, END OF TRACK, AND SAMPLE RATE
55-72	HEXADECIMAL	144	SPARES (EACH UNUSED BIT SET TO 0)
73	HEXADECIMAL	8	04_{16}
74	HEXADECIMAL	8	OF_{16}
75	HEXADECIMAL	8	OF_{16}

f. Bytes 15-18. Constant (00_{16} in each byte). This field usually contains the microseconds of seconds. For reporting TDR Spacecraft data, this field shall be zero.

g. Return Link Ground Antenna Angle. The contents of these fields (bytes 19-22 and bytes 23-26) shall be the ground antenna angles associated with the return link providing the tracking service. Azimuth shall be measured in the local horizontal plane positive clockwise from north. The local horizontal plane is defined to be perpendicular to the local gravitational vertical. Elevation shall be measured positive above local horizontal. The resolution of each angle shall be 0.0055°. These angles shall be reported to the FDF with an uncertainty $\leq 0.03^\circ$. The angles in both fields shall be represented by fractions of a circle. For both fields, the LSB equals $360.\overline{0}^\circ \times 2^{-32}$ and the Most Significant Bit (MSB) equals $180.\overline{0}^\circ$. Bytes 19-22 shall contain azimuth. Bytes 23-26 shall contain elevation.

h. Range. The contents of this field (bytes 27-32) shall be the unambiguous range measurement (total round trip light time for the entire signal propagation path). The Least Significant Bit of this field equals 2^{-8} nanosecond. The measurement resolution and accuracy shall be as follows:

Range resolution (one-way) < 3m

Range accuracy (one way):

1. Range component (thermal noise, quantization error) < 15m (1σ).
2. RMS short-term drift (1 sec. to 24 hrs.) and tracking error < 10m (1σ).
3. Long-Term Systematic error (bias) < 10m.
4. False ambiguity resolution probability < 10^{-3}.

i. Bytes 33-38. Constant (00_{16} in each byte).

j. Bytes 39-40. Spares (all unused bits set to 0).

k. Forward Link Frequency. This field (bytes 41-44) shall contain the forward link center frequency used to track the TDRS. The LSB of this field represents 10 Hz.

l. Forward Link Ground Antenna Size and Type. The contents of this field (byte 45) shall be the forward link ground antenna size and type. Set this field to 60_{16} for the TDRSS 18 m (az-el) K-band antenna and 30_{16} for the 30 ft. (az-el) S-band antenna.

m. Forward Link Ground Antenna ID. The contents of this field (byte 46) shall be the STGT/WSGTU ground antenna ID of the antenna providing the forward link for tracking the TDRS. The ground antenna ID's are:

WSGTU ID	STGT ID	Ground Antenna
9	47	North antenna
10	48	Central antenna
11	49	South antenna
33	25	S-Band antenna

n. Return Link Ground Antenna Size and Type. The contents of this field (byte 47) shall be the return link ground antenna size and type. Set this field to 60_{16} for the TDRSS 18 m (az-el) K-band antenna and 30_{16} for the 30 ft. (az-el) S-band antenna.

o. Return Link Ground Antenna ID. The contents of this field (byte 48) shall be the STGT/WSGTU ground antenna ID of the antenna providing the return link for tracking TDRS. The ground antenna ID's are:

WSGTU ID	STGT ID	Ground Antenna
9	47	North antenna
10	48	Central antenna
11	49	South antenna
33	25	S-Band antenna

p. Status and Configuration Indication. The contents of these fields (bytes 49-50) are shown.

Bits	Name	Values
16-13	Spares	All unused bits set to zero
12	Uplink Equipment Chain	1 = Primary Chain 0 = Secondary Chain

Bits	Name	Values
11	Downlink Equipment Chain	1 = Primary Chain 0 = Secondary Chain
10-5	Spares	All unused bits set to zero
4-3	Track Type	11 = Spare 10 = Manual Track 01 = Program Track 00 = Autotrack
2-1	Spares	All unused bits set to zero

q. Subsystem/Data Validity. The contents of this field (byte 51) shall indicate the validity of the return link antenna angle field (bytes19-26) and the range field (bytes 27-32).

Antenna angles are valid under conditions that include but are not limited to:

1. Antenna is in autotrack mode.
2. Antenna is not exhibiting a major fault or a control fault.
3. Antenna measurements are on time (i.e., there was a measurement update received corresponding to the time tag).

Range data will be valid under conditions that include but are not limited to:

1. The receiver used for the associated downlink has carrier lock.
2. The range tone demodulator has lock.
3. The range equipment used for the tracking service is not exhibiting a fault.

The contents of this field shall be as listed below:

Field Location	Contents
Bit 8	Tracking Subsystem 0 - not used 1 - STGT/WSGTU
Bits 5-7	Spares (unused bits set to zero)
Bit 4	Angle data error model correction applied 0 - not applied 1 - applied
Bit 3	Validity of the antenna angle data in bytes 19-26 0 - not valid 1 - valid
Bit 2	Constant at 0
Bit 1	Range validity 0 - not valid 1 - valid

r. Frequency Band and Service Type. The contents of this field (byte 52) shall be the frequency band of the forward link and the return link of the TDRS being tracked, and the type of service for which tracking is being provided.

The contents of this field shall be as defined below:

Field Location	Contents
MSD	Frequency Band 3_{16}: S-band 6_{16}: K-band
LSD	Service Type 1_{16}: Not Used 4_{16}: Normal Service

s. Tracker Type, End of Track and Sample Rate. The contents of this field (bytes 53-54) shall be the tracker type code for the TDR spacecraft track, an end of track (EOT) indication, and the rate at which the tracking data is sampled.

The contents of this field shall be as defined below:

Field Location	Contents
Byte 53, MSD	Constant (8_{16}) - indicates TDR Spacecraft Tracking System
Byte 53, Bit 4	Last Frame (End of scheduled service; 1 = Yes, 0 = No)
Byte 53, Bit 3	0 - indicates that the next 10 bits (the sample rate) represent the number of seconds between tracking samples (Byte 54, Bit 1 represents 1 second)
Byte 53, Bit 2 to Byte 54, Bit 1	The Sample Rate (see Byte 53, Bit 3 for more information)

t. Bytes 55-72. Spares. Unused spare bits shall be set to zero.

u. Frame Trailer. Bytes 73-75 comprise the frame trailer. Byte 73 is set to 04_{16} and each of bytes 74-75 is set to OF_{16}.

12.1.6 Tracking Data Sample Insertion into 4800-Bit Block

The data field of the 4800-bit data block on the tracking data interface shall contain the SGLT generated tracking data samples. The data field shall contain from one to seven tracking data samples, the number of samples/data field being a function of the number of ongoing SGLT tracking services. The first bit transmitted of the first sample shall be the first bit of the data field (bit 145).

Multiple samples within the data field shall be sample contiguous. The portion of the block data field between the last bit of the last tracking data sample within the data field and the first bit of the block error control word shall contain a fill pattern, $C9_{16}$. The MSB of the fill pattern shall be the first bit transmitted.

TDR spacecraft tracking data shall be packed into 4800 bit blocks separate from 4800 bit blocks containing user spacecraft tracking data. The tracking data samples for different users may be in any order within a 4800 bit block. The tracking data samples for the same user within a 4800 bit block shall be chronologically ordered according to their time tags.

12.2 Supplemental Tracking Parameter Information

a. Interchange of KSA Antennas (F1-F7 only).

The single access antenna along the +x-spacecraft-body axis has been designated as the KSA-1 link. Data received via this antenna is normally placed on a dedicated ground link channel. The single access antenna along the -x-spacecraft-body axis has been designated the KSA-2 link and data received via that antenna is placed on a composite ground link channel. The dedicated downlink channel carries only data received via KSA-1 while the multiplexed downlink channel carries data received via MA antennas, SSA-1 (+x), SSA-2 (-x), KSA-2 and telemetry.

The capability exists to place the data received via the +x SA antenna on the multiplexed downlink channel and the data received on the -x SA antenna on the dedicated downlink channel. This is accomplished by routing the local oscillator 2790 MHz signal (dedicated mixer frequency) to the -x SA antenna electronics, routing the local oscillator 2710 MHz signal (multiplex mixer frequency) to the +x SA antenna electronics, and switching the +x and -x SA antenna electronics output signals inside the return processor to allow the frequency dependent return processor channels to amplify and process the usual signals (even though the usual signals are being received by different SA antennas). See Figure 12-2 for a simplified diagram.

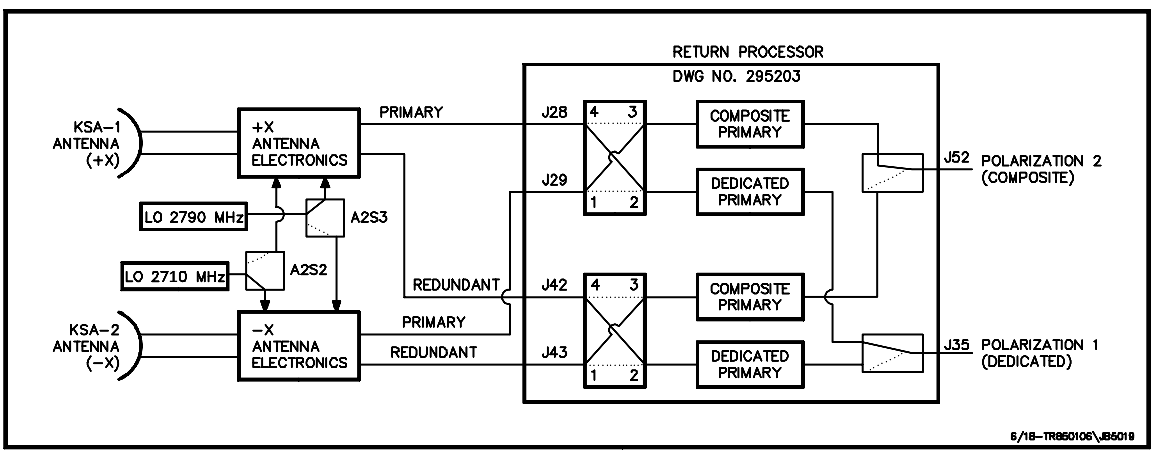


Figure 12-2. KSA Antenna Connectivities

Basically, four commands are required to cause this interchange of links to the +x and -x antennas. Two commands route the correct local oscillator signals to the opposite SA antenna electronics and two commands to the return processor route the Intermediate Frequency (IF) signals to the correct channel. The Local Oscillator (LO) switches depend on which redundant channel in the antenna electronics is being used. Table 12-2 identifies which switches in the Signal Distribution Unit are switched as a function of which redundant channel, A or B, is in use (it is assumed that no redundancy switching takes place in the operation).

Table 12-2. SDU Switching Required to Route the East SA Antenna to Composite and the West SA Antenna to Dedicated

ELECTRONICS	CHANNEL	SDU SWITCH	TERMINAL CHANGES
-x	A	A2S2	J4J3=>J1J3
-x	B	A2S2	J4J2=>J1J2
+x	A	A2S3	J3J1=>J2J1
+x	B	A2S3	J3J4=>J2J4

b. TDRS Orientation.

TDRS earth sensors measure roll and pitch error eight times per second (the sensors oscillate at a 4 Hz rate). These eight measurements are averaged and the resulting values of roll and pitch are placed into a telemetry data buffer, to be telemetered every 512 msec.

Spacecraft roll and Yaw rates are maximum (of order 10^{-3} to 10^{-2}°/sec) during SA antenna slewing operations. Roll and pitch uncertainty is 0.1° while Yaw uncertainty is 0.25° (Yaw can be measured accurately only at 6am and 6pm). Pitch is actively controlled by momentum wheel motor torque to about 0.05° except during SA antenna slewing operations. Maximum pitch is expected to be less than 1° and the maximum pitch rate is of order 10^{-2}°/sec. Both maxima (pitch and pitch rate) occur when both SA antennas are simultaneously slewed north (or south) at a maximum rate.

Yaw error is estimated between 9 pm and 3 am and between 9 am and 3 pm using earth sensor (roll) measurements and reaction wheel speeds. Between 3 am and 9 am and between 3 pm and 9 pm, Yaw error is measured by the fine sun sensor (every 512 ms). The Yaw error is measured directly at exactly 6 am and 6 pm. At precisely noon and midnight (non-eclipse) the fine sun sensor measures roll angle directly and can be calibrated with the earth sensor roll measurements.

c. Two-way Doppler Reference Frequency.

For two-way Doppler tracking, forward Doppler compensation is, of course, inhibited. Such inhibition is accomplished only when a Doppler compensation inhibit request is received via OPM from the NCC. During inhibit mode, the TDRS forward transmit frequency is held constant (frozen) such that the reference frequency for two-way Doppler measurement is an integral multiple of 10 Hz. Since the reference frequency is the user transmit frequency, which is coherently related to the TDRS forward transmit frequency by the coherent turnaround ratio (240/221 @ S-Band and 160/146.9 @ K-Band), this can be accomplished by freezing the TDRS forward transmit frequency at an integral multiple of 221 at S-Band and 146.9 at K-Band. The reference frequency is therefore given by:

$$f_{(ref-S)} = f_{TS}\left(\frac{240}{221}\right) @ \mathrm{S-Band}$$

and

$$f_{(ref-K)} = f_{TK}\left(\frac{1600}{1469}\right) @ \mathrm{K-Band}$$

where f_{TS} and f_{TK} are the TDRS forward transmit frequencies at S- and K-Band, respectively, after Doppler compensation has been accomplished.

In the case where Doppler compensation is not being performed, and Doppler tracking is required, a momentary Doppler compensation is made and immediately inhibited, leading to the same derivation of the above expressions for the Doppler reference frequency.

Section 13. Character Set For Free-Form Text Messages

	STD. CHARACTER CONFIGURATIONS	ASCII
		MSB LSB
CONFIGUR-ATION	NAME/DESCRIPTION	7 6 5 4 3 2 1
SP	Space (Blank)	0 1 0 0 0 0 0
!	Exclamation Point	0 1 0 0 0 0 1
"	Quotation Mark	0 1 0 0 0 1 0
#	Number or Pound Symbol	0 1 0 0 0 1 1
$	Dollar Symbol	0 1 0 0 1 0 0
%	Percent Symbol	0 1 0 0 1 0 1
&	And Symbol	0 1 0 0 1 1 0
’	Apostrophe	0 1 0 0 1 1 1
(	Left Parenthesis Mark	0 1 0 1 0 0 0
)	Right Parenthesis Mark	0 1 0 1 0 0 1
*	Asterisk Mark	0 1 0 1 0 1 0
+	Plus Sign	0 1 0 1 0 1 1
,	Comma	0 1 0 1 1 0 0
-	Minus Sign	0 1 0 1 1 0 1
.	Period or Decimal Point	0 1 0 1 1 1 0
/	Diagonal	0 1 0 1 1 1 1
0	Number 0	0 1 1 0 0 0 0
1	Number 1	0 1 1 0 0 0 1
2	Number 2	0 1 1 0 0 1 0
3	Number 3	0 1 1 0 0 1 1
4	Number 4	0 1 1 0 1 0 0
5	Number 5	0 1 1 0 1 0 1
6	Number 6	0 1 1 0 1 1 0
7	Number 7	0 1 1 0 1 1 1
8	Number 8	0 1 1 1 0 0 0

	STD. CHARACTER CONFIGURATIONS	ASCII
		MSB LSB
CONFIGUR-ATION	NAME/DESCRIPTION	7 6 5 4 3 2 1
9	Number 9	0 1 1 1 0 0 1
:	Colon	0 1 1 1 0 1 0
;	Semicolon	0 1 1 1 0 1 1
<	Less than Sign	0 1 1 1 1 0 0
=	Equal Sign	0 1 1 1 1 0 1
>	Greater than Sign	0 1 1 1 1 1 0
?	Question Mark	0 1 1 1 1 1 1
@	At Symbol	1 0 0 0 0 0 0
A	Capital Letter A	1 0 0 0 0 0 1
B	Capital Letter B	1 0 0 0 0 1 0
C	Capital Letter C	1 0 0 0 0 1 1
D	Capital Letter D	1 0 0 0 1 0 0
E	Capital Letter E	1 0 0 0 1 0 1
F	Capital Letter F	1 0 0 0 1 1 0
G	Capital Letter G	1 0 0 0 1 1 1
H	Capital Letter H	1 0 0 1 0 0 0
I	Capital Letter I	1 0 0 1 0 0 1
J	Capital Letter J	1 0 0 1 0 1 0
K	Capital Letter K	1 0 0 1 0 1 1
L	Capital Letter L	1 0 0 1 1 0 0
M	Capital Letter M	1 0 0 1 1 0 1
N	Capital Letter N	1 0 0 1 1 l 0
O	Capital Letter O	1 0 0 1 1 1 1
P	Capital Letter P	1 0 1 0 0 0 0
Q	Capital Letter Q	1 0 1 0 0 0 1
R	Capital Letter R	1 0 1 0 0 1 0
S	Capital Letter S	1 0 1 0 0 1 1
T	Capital Letter T	1 0 1 0 1 0 0
U	Capital Letter U	1 0 1 0 1 0 1

	STD. CHARACTER CONFIGURATIONS	ASCII
		MSB LSB
CONFIGUR-ATION	NAME/DESCRIPTION	7 6 5 4 3 2 1
V	Capital Letter V	1 0 1 0 1 1 0
W	Capital Letter W	1 0 1 0 1 1 1
X	Capital Letter X	1 0 1 1 0 0 0
Y	Capital Letter Y	1 0 1 1 0 0 1
Z	Capital Letter Z	1 0 1 1 0 1 0
[	Open Bracket	1 0 1 1 0 1 1
\	Reverse Slant	1 0 1 1 1 0 0
]	Closed Bracket	1 0 1 1 1 0 1
^	Caret	1 0 1 1 1 1 0
-	Underline	1 0 1 1 1 1 1

Abbreviations and Acronyms

ACS	Attitude Control System
ADPE	Automatic Data Processing Equipment
ASCII	American Standard Code for Information Interchange
BED	Block Error Detector
BER	Bit Error Rate
BPSK	Binary Phase Shift Keying
BR	Bit Rate
CAB	Circuit Assurance Block
CCB	Configuration Control Board
CCR	Configuration Change Request
CDCN	Control and Display Computer Network
CMD	Command
CTFS	Common Time and Frequency System
DCN	Document Change Notice
DEMUX	Demultiplexer
DG	Data Group
DIS	Data Interface System
DQM	Data Quality Monitor
EET	End-to-End Test
EIRP	Effective Isotropic Radiated Power
EOT	End of Track
EXEC	Executive
ETRO	Estimated Time of Return to Operation
FDF	Flight Dynamics Facility
GMT	Greenwich Mean Time
GSFC	Goddard Space Flight Center
G/T	Gain to Noise Temperature Ratio

GT	Ground Terminal
HDR	High Data Rate
HDRD	High Data Rate Demultiplexer
HDRM	High Data Rate Multiplexer
HDRR	High Data Rate Receiver
HRBS	High Rate Black Switch
HSM	Hot Standby Mode
I	In-Phase (channel)
ICD	Interface Control Document
IF	Intermediate Frequency
IIRV	Improved Interrange Vector
IR	Integrated Receiver
JPL	Jet Propulsion Laboratory
JSC	Johnson Space Center
Kbps	Kilobits Per Second
KaSA	Ka-Band Single Access
KSA	Ku-Band Single Access
KaSAF	Ka-Band Single Access Forward
KSAF	Ku-Band Single Access Forward
KaSAR	Ka-Band Single Access Return
KSAR	Ku-Band Single Access Return
KSH	Ku-Band Shuttle
LAN	Local Area Network
LCP	Left-Hand Circular Polarization
LI	Local Interface
LO	Local Oscillator
LOR	Line Outage Recorder
LRBS	Low Rate Black Switch
LRD	Low Rate Demodulator
LSB	Least Significant Bit or Byte

LSD	Logistics Support Depot
LSD	Least Significant Digit
MA	Multiple Access
MAF	Multiple Access Forward
MAR	Multiple Access Return
Mbps	Megabits Per Second
MCC	Message Class Codes
MDM	Multiplexer/Demultiplexer
MHz	Mega Hertz
MO&DSD	Mission Operations and Data Systems Directorate
MS	Mission Support
MSB	Most Significant Bit
MSD	Most Significant Digit
MSM	Maintenance and Software Delivery Mode
MUX	Multiplexer
NASA	National Aeronautics and Space Administration
NASCOM	NASA Communications Network
NCC	Network Control Center
NCCDS	Network Control Center Data System
ND	Networks Division
NGT	NASA Ground Terminal
NRZ	Non-Return to Zero
NRZ-L	Non-Return to Zero-Level
NRZ-M	Non-Return to Zero-Mark
NRZ-S	Non-Return to Zero-Space
ODM	Operations Data Messages
OPM	Operations Messages
PDA	Pin Diode Attenuator
PM	Preventative Maintenance
PMMS	Performance Measuring and Monitoring Subsystem

PTE	PMMS Test Equipment	
QPSK	Quadrature Phase Shift Keying	
RCP	Right-Hand Circular Polarization	
RF	Radio Frequency	
SA	Single Access	
SDU	Signal Distribution Unit	
SGLT	Space Ground Link Terminal	
SHO	Schedule Order	
SIC	Support Identification Code	
SLR	Service Level Report	
SMA	S-Band Multiple Access	S-Band Multiple Access refers to the MA services provided by TDRSs with ID's 1307, 1308 or 1309.
SMAF	S-Band Multiple Access Forward	
SMAR	S-Band Multiple Access Return	
SQPSK	Staggered Quadrature Phase Shift Keying	
SRDP	Shuttle Return Data Processor	
SSA	S-Band Single Access	
SSAF	S-Band Single Access Forward	
SSAR	S-Band Single Access Return	
SSH	S-Band Shuttle	
STGT	Second (TDRSS) Ground Terminal/Danzante Ground Terminal	
SUE	Shuttle-Unique Equipment	
SUPIDEN	Support Identifier	
T&C	Telemetry and Command	
TDM	Tracking Data Messages	
TDR	Tracking and Data Relay	
TDRS	Tracking and Data Relay Satellite	
TDRSS	Tracking and Data Relay Satellite System	
TLM	Telemetry	
TOCC2	TDRSS Operations and Control Center at STGT	
TT&C	Tracking, Telemetry and Command	

TV	Television
USS	User Services Subsystem
UTC	Coordinated Universal Time
VIC	Vehicle Identification Code
WSC	White Sands Complex
WSGTU	White Sands Ground Terminal Upgrade/Cacique Ground Terminal
X MUX	Cross-Strapping Multiplexer